

Neutral Higgs Bosons, Searches for

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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 $b\bar{b}b\bar{b}$ and $b\bar{b}\tau^+\tau^-$. In $p\bar{p}$ 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 \tilde{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^{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

<u>VALUE (GeV)</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
>89.7		¹ ABDALLAH 08B	DLPH	$E_{\text{cm}} \leq 209 \text{ GeV}$
>92.8	95	² SCHAEEL 06B	LEP	$E_{\text{cm}} \leq 209 \text{ GeV}$
>84.5	95	^{3,4} ABBIENDI 04M	OPAL	$E_{\text{cm}} \leq 209 \text{ GeV}$
>86.0	95	^{3,5} ACHARD 02H	L3	$E_{\text{cm}} \leq 209 \text{ GeV}, \tan\beta > 0.4$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●				
		⁶ AABOUD 16AA	ATLS	$H_2^0 \rightarrow \tau^+ \tau^-$
		⁷ KHACHATRY...16A	CMS	$H_{1,2}^0/A^0 \rightarrow \mu^+ \mu^-$
		⁸ AAD 15CE	ATLS	$H_2^0 \rightarrow H^0 H^0$
		⁹ KHACHATRY...15AY	CMS	$pp \rightarrow H_{1,2}^0/A^0 + b + X,$ $H_{1,2}^0/A^0 \rightarrow b\bar{b}$
		¹⁰ AAD 14AW	ATLS	$pp \rightarrow H_{1,2}^0/A^0 + X,$ $H_{1,2}^0/A^0 \rightarrow \tau\tau$
		¹¹ KHACHATRY...14M	CMS	$pp \rightarrow H_{1,2}^0/A^0 + X,$ $H_{1,2}^0/A^0 \rightarrow \tau\tau$
		¹² AAD 13O	ATLS	$pp \rightarrow H_{1,2}^0/A^0 + X,$ $H_{1,2}^0/A^0 \rightarrow \tau^+ \tau^-, \mu^+ \mu^-$
		¹³ AAIJ 13T	LHCB	$pp \rightarrow H_{1,2}^0/A^0 + X,$ $H_{1,2}^0/A^0 \rightarrow \tau^+ \tau^-$
		¹⁴ CHATRCHYAN 13AG	CMS	$pp \rightarrow H_{1,2}^0/A^0 + b + X,$ $H_{1,2}^0/A^0 \rightarrow b\bar{b}$
		¹⁵ AALTONEN 12AQ	TEVA	$p\bar{p} \rightarrow H_{1,2}^0/A^0 + b + X,$ $H_{1,2}^0/A^0 \rightarrow b\bar{b}$
		¹⁶ AALTONEN 12X	CDF	$p\bar{p} \rightarrow H_{1,2}^0/A^0 + b + X,$ $H_{1,2}^0/A^0 \rightarrow b\bar{b}$
		¹⁷ ABAZOV 12G	D0	$p\bar{p} \rightarrow H_{1,2}^0/A^0 + X,$ $H_{1,2}^0/A^0 \rightarrow \tau^+ \tau^-$
		¹⁸ CHATRCHYAN 12K	CMS	$pp \rightarrow H_{1,2}^0/A^0 + X,$ $H_{1,2}^0/A^0 \rightarrow \tau^+ \tau^-$
		¹⁹ ABAZOV 11K	D0	$p\bar{p} \rightarrow H_{1,2}^0/A^0 + b + X,$ $H_{1,2}^0/A^0 \rightarrow b\bar{b}$

	20	ABAZOV	11W D0	$p\bar{p} \rightarrow H_{1,2}^0/A^0 + b + X,$ $H_{1,2}^0/A^0 \rightarrow \tau^+\tau^-$
	21	AALTONEN	09AR CDF	$p\bar{p} \rightarrow H_{1,2}^0/A^0 + X,$ $H_{1,2}^0/A^0 \rightarrow \tau^+\tau^-$
	22	ABBIENDI	03G OPAL	$H_1^0 \rightarrow A^0 A^0$
>89.8	95	3,23 HEISTER	02 ALEP	$E_{\text{cm}} \leq 209 \text{ GeV}, \tan\beta > 0.5$

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 SCHAEEL 06B make a combined analysis of the LEP data. The quoted limit is for the m_h^{max} scenario with $m_t = 174.3 \text{ GeV}$. 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 $\sigma(ZH^0) \cdot B(H^0 \rightarrow b\bar{b}, \tau^+\tau^-)$ and $\sigma(H_1^0 H_2^0) \cdot B(H_1^0, H_2^0 \rightarrow b\bar{b}, \tau^+\tau^-)$.

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

⁴ ABBIENDI 04M exclude $0.7 < \tan\beta < 1.9$, assuming $m_t = 174.3 \text{ GeV}$. 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 $H_1^0 Z \rightarrow 2A^0 q\bar{q}$, $A^0 \rightarrow q\bar{q}$. In addition, the MSSM parameter set in the “large- μ ” and “no-mixing” scenarios are examined.

⁶ AABOUD 16AA search for production of a Higgs boson in gluon fusion and in association with a $b\bar{b}$ pair followed by the decay $H_2^0 \rightarrow \tau^+\tau^-$ in 3.2 fb^{-1} of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$. See their Fig. 5(a, b) for limits on cross section times branching ratio for $m_{H_2^0} = 200\text{--}1200 \text{ GeV}$, and Fig. 5(c, d) for the excluded region in the MSSM parameter space in the $m_h^{\text{mod+}}$ and hMSSM scenarios.

⁷ KHACHATRYAN 16A search for production of a Higgs boson in gluon fusion and in association with a $b\bar{b}$ pair followed by the decay $H_{1,2}^0/A^0 \rightarrow \mu^+\mu^-$ in 5.1 fb^{-1} of pp collisions at $E_{\text{cm}} = 7 \text{ TeV}$ and 19.3 fb^{-1} at $E_{\text{cm}} = 8 \text{ TeV}$. See their Fig. 7 for the excluded region in the MSSM parameter space in the $m_h^{\text{mod+}}$ benchmark scenario and Fig. 9 for limits on cross section times branching ratio.

⁸ AAD 15CE search for production of H_2^0 decaying to $H^0 H^0$ in the final states $b\bar{b}\tau^+\tau^-$ and $\gamma\gamma WW^*$ in 20.3 fb^{-1} of pp collisions at $E_{\text{cm}} = 8 \text{ TeV}$ and combine with data from AAD 15H ($\gamma\gamma b\bar{b}$) and AAD 15BK ($b\bar{b}b\bar{b}$). See their Fig. 7 for excluded regions in the parameter space in several scenarios.

⁹ KHACHATRYAN 15AY search for production of a Higgs boson in association with a b quark in the decay $H_{1,2}^0/A^0 \rightarrow b\bar{b}$ in 19.7 fb^{-1} of pp collisions at $E_{\text{cm}} = 8 \text{ TeV}$ and combine with CHATRCHYAN 13AG 7 TeV data. See their Fig. 6 for the limits on cross section times branching ratio for $m_{A^0} = 100\text{--}900 \text{ GeV}$ and Figs. 7–9 for the excluded region in the MSSM parameter space in various benchmark scenarios.

¹⁰ AAD 14AW search for production of a Higgs boson followed by the decay $H_{1,2}^0/A^0 \rightarrow \tau^+\tau^-$ in $19.5\text{--}20.3 \text{ fb}^{-1}$ of pp collisions at $E_{\text{cm}} = 8 \text{ TeV}$. 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 $m_{A^0} = 140 \text{ GeV}$, the region $\tan\beta > 5.4$ is excluded at 95% CL in the m_h^{max} scenario.

- ¹¹ KHACHATRYAN 14M search for production of a Higgs boson in gluon fusion and in association with a b quark followed by the decay $H_{1,2}^0/A^0 \rightarrow \tau^+\tau^-$ in 4.9 fb^{-1} of pp collisions at $E_{\text{cm}} = 7 \text{ TeV}$ and 19.7 fb^{-1} at $E_{\text{cm}} = 8 \text{ TeV}$. 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 $m_{A^0} = 140 \text{ GeV}$, the region $\tan\beta > 3.8$ is excluded at 95% CL in the m_h^{max} scenario.
- ¹² AAD 13O search for production of a Higgs boson in the decay $H_{1,2}^0/A^0 \rightarrow \tau^+\tau^-$ and $\mu^+\mu^-$ with $4.7\text{--}4.8 \text{ fb}^{-1}$ of pp collisions at $E_{\text{cm}} = 7 \text{ TeV}$. 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 $m_{A^0} = 110\text{--}170 \text{ GeV}$, $\tan\beta \gtrsim 10$ is excluded, and for $\tan\beta = 50$, m_{A^0} below 470 GeV is excluded at 95% CL in the m_h^{max} scenario.
- ¹³ AAIJ 13T search for production of a Higgs boson in the forward region in the decay $H_{1,2}^0/A^0 \rightarrow \tau^+\tau^-$ in 1.0 fb^{-1} of pp collisions at $E_{\text{cm}} = 7 \text{ TeV}$. See their Fig. 2 for the limits on cross section times branching ratio and the excluded region in the MSSM parameter space.
- ¹⁴ CHATRCHYAN 13AG search for production of a Higgs boson in association with a b quark in the decay $H_{1,2}^0/A^0 \rightarrow b\bar{b}$ in $2.7\text{--}4.8 \text{ fb}^{-1}$ of pp collisions at $E_{\text{cm}} = 7 \text{ TeV}$. 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 $m_{A^0} = 90\text{--}350 \text{ GeV}$, upper bounds on $\tan\beta$ of $18\text{--}42$ at 95% CL are obtained in the m_h^{max} scenario with $\mu = +200 \text{ GeV}$.
- ¹⁵ 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.
- ¹⁶ AALTONEN 12X search for associated production of a Higgs boson and a b quark in the decay $H_{1,2}^0/A^0 \rightarrow b\bar{b}$, with 2.6 fb^{-1} of $p\bar{p}$ collisions at $E_{\text{cm}} = 1.96 \text{ TeV}$. 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.
- ¹⁷ ABAZOV 12G search for production of a Higgs boson in the decay $H_{1,2}^0/A^0 \rightarrow \tau^+\tau^-$ with 7.3 fb^{-1} of $p\bar{p}$ collisions at $E_{\text{cm}} = 1.96 \text{ TeV}$ 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 $m_{A^0} = 90\text{--}180 \text{ GeV}$, $\tan\beta \gtrsim 30$ is excluded at 95% CL in the m_h^{max} scenario.
- ¹⁸ CHATRCHYAN 12K search for production of a Higgs boson in the decay $H_{1,2}^0/A^0 \rightarrow \tau^+\tau^-$ with 4.6 fb^{-1} of pp collisions at $E_{\text{cm}} = 7 \text{ TeV}$. See their Fig. 3 and Table 4 for the excluded region in the MSSM parameter space. For $m_{A^0} = 160 \text{ GeV}$, the region $\tan\beta > 7.1$ is excluded at 95% CL in the m_h^{max} scenario. Superseded by KHACHATRYAN 14M.
- ¹⁹ ABAZOV 11K search for associated production of a Higgs boson and a b quark, followed by the decay $H_{1,2}^0/A^0 \rightarrow b\bar{b}$, in 5.2 fb^{-1} of $p\bar{p}$ collisions at $E_{\text{cm}} = 1.96 \text{ TeV}$. 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 $\mu = -200 \text{ GeV}$.
- ²⁰ ABAZOV 11W search for associated production of a Higgs boson and a b quark, followed by the decay $H_{1,2}^0/A^0 \rightarrow \tau\tau$, in 7.3 fb^{-1} of $p\bar{p}$ collisions at $E_{\text{cm}} = 1.96 \text{ TeV}$. See their Fig. 2 for the limit on cross section times branching ratio and for the excluded region in the MSSM parameter space.
- ²¹ AALTONEN 09AR search for Higgs bosons decaying to $\tau^+\tau^-$ in two doublet models in 1.8 fb^{-1} of $p\bar{p}$ collisions at $E_{\text{cm}} = 1.96 \text{ TeV}$. 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.

²² ABBIENDI 03G search for $e^+e^- \rightarrow H_1^0 Z$ followed by $H_1^0 \rightarrow A^0 A^0$, $A^0 \rightarrow c\bar{c}$, $g\bar{g}$, or $\tau^+\tau^-$. In the no-mixing scenario, the region $m_{H_1^0} = 45\text{-}85$ GeV and $m_{A^0} = 2\text{-}9.5$ GeV is excluded at 95% CL.

²³ HEISTER 02 excludes the range $0.7 < \tan\beta < 2.3$. 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	$E_{\text{cm}} \leq 209$ GeV
>93.4	95	2 SCHAEEL 06B	LEP	$E_{\text{cm}} \leq 209$ GeV
>85.0	95	3,4 ABBIENDI 04M	OPAL	$E_{\text{cm}} \leq 209$ GeV
>86.5	95	3,5 ACHARD 02H	L3	$E_{\text{cm}} \leq 209$ GeV, $\tan\beta > 0.4$
>90.1	95	3,6 HEISTER 02	ALEP	$E_{\text{cm}} \leq 209$ GeV, $\tan\beta > 0.5$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●				
		7 AABOUD 18G	ATLS	$H_2^0/A^0 \rightarrow \tau^+\tau^-$
		8 SIRUNYAN 18A	CMS	$H_2^0/A^0 \rightarrow H^0 H^0$
		9 AABOUD 16AA	ATLS	$A^0 \rightarrow \tau^+\tau^-$
		10 KHACHATRY...16A	CMS	$H_{1,2}^0/A^0 \rightarrow \mu^+\mu^-$
		11 KHACHATRY...16P	CMS	$H_2^0 \rightarrow H^0 H^0$, $A^0 \rightarrow Z H^0$
		12 KHACHATRY...15AY	CMS	$pp \rightarrow H_{1,2}^0/A^0 + b + X$, $H_{1,2}^0/A^0 \rightarrow b\bar{b}$
		13 AAD 14AW	ATLS	$pp \rightarrow H_{1,2}^0/A^0 + X$, $H_{1,2}^0/A^0 \rightarrow \tau\tau$
		14 KHACHATRY...14M	CMS	$pp \rightarrow H_{1,2}^0/A^0 + X$, $H_{1,2}^0/A^0 \rightarrow \tau\tau$
		15 AAD 13O	ATLS	$pp \rightarrow H_{1,2}^0/A^0 + X$, $H_{1,2}^0/A^0 \rightarrow \tau^+\tau^-, \mu^+\mu^-$
		16 AAIJ 13T	LHCB	$pp \rightarrow H_{1,2}^0/A^0 + X$, $H_{1,2}^0/A^0 \rightarrow \tau^+\tau^-$
		17 CHATRCHYAN 13AG	CMS	$pp \rightarrow H_{1,2}^0/A^0 + b + X$, $H_{1,2}^0/A^0 \rightarrow b\bar{b}$
		18 AALTONEN 12AQ	TEVA	$p\bar{p} \rightarrow H_{1,2}^0/A^0 + b + X$, $H_{1,2}^0/A^0 \rightarrow b\bar{b}$
		19 AALTONEN 12X	CDF	$p\bar{p} \rightarrow H_{1,2}^0/A^0 + b + X$, $H_{1,2}^0/A^0 \rightarrow b\bar{b}$
		20 ABAZOV 12G	D0	$p\bar{p} \rightarrow H_{1,2}^0/A^0 + X$, $H_{1,2}^0/A^0 \rightarrow \tau^+\tau^-$
		21 CHATRCHYAN 12K	CMS	$pp \rightarrow H_{1,2}^0/A^0 + X$, $H_{1,2}^0/A^0 \rightarrow \tau^+\tau^-$

22	ABAZOV	11K D0	$p\bar{p} \rightarrow H_{1,2}^0/A^0 + b + X,$ $H_{1,2}^0/A^0 \rightarrow b\bar{b}$
23	ABAZOV	11W D0	$p\bar{p} \rightarrow H_{1,2}^0/A^0 + b + X,$ $H_{1,2}^0/A^0 \rightarrow \tau^+\tau^-$
24	AALTONEN	09AR CDF	$p\bar{p} \rightarrow H_{1,2}^0/A^0 + X,$ $H_{1,2}^0/A^0 \rightarrow \tau^+\tau^-$
25	ACOSTA	05Q CDF	$p\bar{p} \rightarrow H_{1,2}^0/A^0 + X$
26	ABBIENDI	03G OPAL	$H_1^0 \rightarrow A^0 A^0$
27	AKERROYD	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 SCHAEEL 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 $\sigma(ZH^0) \cdot B(H^0 \rightarrow b\bar{b}, \tau^+\tau^-)$ and $\sigma(H_1^0 H_2^0) \cdot B(H_1^0, H_2^0 \rightarrow b\bar{b}, \tau^+\tau^-)$.

³ Search for $e^+e^- \rightarrow H_1^0 A^0$ in the final states $b\bar{b}b\bar{b}$ and $b\bar{b}\tau^+\tau^-$, and $e^+e^- \rightarrow H_1^0 Z$. 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 $H_1^0 Z \rightarrow 2A^0 q\bar{q}$, $A^0 \rightarrow q\bar{q}$. 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 AABOUD 18G search for production of $H_2^0/A^0 \rightarrow \tau^+\tau^-$ by gluon fusion and b -associated production in 36.1 fb^{-1} of pp collisions at $E_{\text{cm}} = 13$ TeV. See their Fig. 7 for the limits on cross section times branching ratio for $m_{H_2^0}, m_{A^0} = 0.2\text{--}2.25$ TeV, and Fig. 10 for excluded regions in the $m_{A^0} - \tan\beta$ plane in several MSSM scenarios.

⁸ SIRUNYAN 18A search for production of a scalar resonance decaying to $H^0 H^0 \rightarrow b\bar{b}\tau^+\tau^-$ in 35.9 fb^{-1} of pp collisions at $E_{\text{cm}} = 13$ TeV. See their Fig. 5 for the limits on cross section times branching ratio for the resonance mass = 250–900 GeV and also for excluded regions in the $m_{A^0} - \tan(\beta)$ plane in the hMSSM scenario.

⁹ AABOUD 16AA search for production of a Higgs boson in gluon fusion and in association with a $b\bar{b}$ pair followed by the decay $A^0 \rightarrow \tau^+\tau^-$ in 3.2 fb^{-1} of pp collisions at $E_{\text{cm}} = 13$ TeV. See their Fig. 5(a, b) for limits on cross section times branching ratio for $m_{A^0} = 200\text{--}1200$ GeV, and Fig. 5(c, d) for the excluded region in the MSSM parameter space in the $m_h^{\text{mod}+}$ and hMSSM scenarios.

¹⁰ KHACHATRYAN 16A search for production of a Higgs boson in gluon fusion and in association with a $b\bar{b}$ pair followed by the decay $H_{1,2}^0/A^0 \rightarrow \mu^+\mu^-$ in 5.1 fb^{-1} of pp collisions at $E_{\text{cm}} = 7$ TeV and 19.3 fb^{-1} at $E_{\text{cm}} = 8$ TeV. See their Fig. 7 for the excluded region in the MSSM parameter space in the $m_h^{\text{mod}+}$ benchmark scenario and Fig. 9 for limits on cross section times branching ratio.

- 11 KHACHATRYAN 16P search for gluon fusion production of an H_2^0 decaying to $H^0 H^0 \rightarrow b\bar{b}\tau^+\tau^-$ and an A^0 decaying to $ZH^0 \rightarrow \ell^+\ell^-\tau^+\tau^-$ in 19.7 fb^{-1} of pp collisions at $E_{\text{cm}} = 8 \text{ TeV}$. See their Fig. 12 for excluded region in the $\tan\beta - \cos(\beta - \alpha)$ plane for $m_{H_2^0} = m_{A^0} = 300 \text{ GeV}$.
- 12 KHACHATRYAN 15AY search for production of a Higgs boson in association with a b quark in the decay $H_{1,2}^0/A^0 \rightarrow b\bar{b}$ in 19.7 fb^{-1} of pp collisions at $E_{\text{cm}} = 8 \text{ TeV}$ and combine with CHATRCHYAN 13AG 7 TeV data. See their Fig. 6 for the limits on cross section times branching ratio for $m_{A^0} = 100\text{--}900 \text{ GeV}$ and Figs. 7–9 for the excluded region in the MSSM parameter space in various benchmark scenarios.
- 13 AAD 14AW search for production of a Higgs boson followed by the decay $H_{1,2}^0/A^0 \rightarrow \tau^+\tau^-$ in $19.5\text{--}20.3 \text{ fb}^{-1}$ of pp collisions at $E_{\text{cm}} = 8 \text{ TeV}$. 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 $m_{A^0} = 140 \text{ GeV}$, the region $\tan\beta > 5.4$ is excluded at 95% CL in the m_h^{max} scenario.
- 14 KHACHATRYAN 14M search for production of a Higgs boson in gluon fusion and in association with a b quark followed by the decay $H_{1,2}^0/A^0 \rightarrow \tau^+\tau^-$ in 4.9 fb^{-1} of pp collisions at $E_{\text{cm}} = 7 \text{ TeV}$ and 19.7 fb^{-1} at $E_{\text{cm}} = 8 \text{ TeV}$. 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 $m_{A^0} = 140 \text{ GeV}$, the region $\tan\beta > 3.8$ is excluded at 95% CL in the m_h^{max} scenario.
- 15 AAD 13O search for production of a Higgs boson in the decay $H_{1,2}^0/A^0 \rightarrow \tau^+\tau^-$ and $\mu^+\mu^-$ with $4.7\text{--}4.8 \text{ fb}^{-1}$ of pp collisions at $E_{\text{cm}} = 7 \text{ TeV}$. 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 $m_{A^0} = 110\text{--}170 \text{ GeV}$, $\tan\beta \gtrsim 10$ is excluded, and for $\tan\beta = 50$, m_{A^0} below 470 GeV is excluded at 95% CL in the m_h^{max} scenario.
- 16 AAIJ 13T search for production of a Higgs boson in the forward region in the decay $H_{1,2}^0/A^0 \rightarrow \tau^+\tau^-$ in 1.0 fb^{-1} of pp collisions at $E_{\text{cm}} = 7 \text{ TeV}$. See their Fig. 2 for the limits on cross section times branching ratio and the excluded region in the MSSM parameter space.
- 17 CHATRCHYAN 13AG search for production of a Higgs boson in association with a b quark in the decay $H_{1,2}^0/A^0 \rightarrow b\bar{b}$ in $2.7\text{--}4.8 \text{ fb}^{-1}$ of pp collisions at $E_{\text{cm}} = 7 \text{ TeV}$. 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 $m_{A^0} = 90\text{--}350 \text{ GeV}$, upper bounds on $\tan\beta$ of $18\text{--}42$ at 95% CL are obtained in the m_h^{max} scenario with $\mu = +200 \text{ GeV}$.
- 18 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.
- 19 AALTONEN 12X search for associated production of a Higgs boson and a b quark in the decay $H_{1,2}^0/A^0 \rightarrow b\bar{b}$, with 2.6 fb^{-1} of $p\bar{p}$ collisions at $E_{\text{cm}} = 1.96 \text{ TeV}$. 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.
- 20 ABAZOV 12G search for production of a Higgs boson in the decay $H_{1,2}^0/A^0 \rightarrow \tau^+\tau^-$ with 7.3 fb^{-1} of $p\bar{p}$ collisions at $E_{\text{cm}} = 1.96 \text{ TeV}$ 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 $m_{A^0} = 90\text{--}180 \text{ GeV}$, $\tan\beta \gtrsim 30$ is excluded at 95% CL. in the m_h^{max} scenario.

- 21 CHATRCHYAN 12K search for production of a Higgs boson in the decay $H_{1,2}^0/A^0 \rightarrow \tau^+\tau^-$ with 4.6 fb^{-1} of $p\bar{p}$ collisions at $E_{\text{cm}} = 7 \text{ TeV}$. See their Fig. 3 and Table 4 for the excluded region in the MSSM parameter space. For $m_{A^0} = 160 \text{ GeV}$, the region $\tan\beta > 7.1$ is excluded at 95% CL in the m_h^{max} scenario. Superseded by KHACHATRYAN 14M.
- 22 ABAZOV 11K search for associated production of a Higgs boson and a b quark, followed by the decay $H_{1,2}^0/A^0 \rightarrow b\bar{b}$, in 5.2 fb^{-1} of $p\bar{p}$ collisions at $E_{\text{cm}} = 1.96 \text{ TeV}$. 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 $\mu = -200 \text{ GeV}$.
- 23 ABAZOV 11W search for associated production of a Higgs boson and a b quark, followed by the decay $H_{1,2}^0/A^0 \rightarrow \tau\tau$, in 7.3 fb^{-1} of $p\bar{p}$ collisions at $E_{\text{cm}} = 1.96 \text{ TeV}$. See their Fig. 2 for the limit on cross section times branching ratio and for the excluded region in the MSSM parameter space.
- 24 AALTONEN 09AR search for Higgs bosons decaying to $\tau^+\tau^-$ in two doublet models in 1.8 fb^{-1} of $p\bar{p}$ collisions at $E_{\text{cm}} = 1.96 \text{ TeV}$. See their Fig. 2 for the limit on $\sigma \cdot \text{B}(H_{1,2}^0/A^0 \rightarrow \tau^+\tau^-)$ for different Higgs masses, and see their Fig. 3 for the excluded region in the MSSM parameter space.
- 25 ACOSTA 05Q search for $H_{1,2}^0/A^0$ production in $p\bar{p}$ collisions at $E_{\text{cm}} = 1.8 \text{ TeV}$ with $H_{1,2}^0/A^0 \rightarrow \tau^+\tau^-$. At $m_{A^0} = 100 \text{ GeV}$, the obtained cross section upper limit is above theoretical expectation.
- 26 ABBIENDI 03G search for $e^+e^- \rightarrow H_1^0 Z$ followed by $H_1^0 \rightarrow A^0 A^0$, $A^0 \rightarrow c\bar{c}$, $g g$, or $\tau^+\tau^-$. In the no-mixing scenario, the region $m_{H_1^0} = 45\text{-}85 \text{ GeV}$ and $m_{A^0} = 2\text{-}9.5 \text{ GeV}$ is excluded at 95% CL.
- 27 AKEROYD 02 examine the possibility of a light A^0 with $\tan\beta < 1$. 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 AABOUD	17AN ATLS	$H_2^0, A^0 \rightarrow t\bar{t}$

		2	SIRUNYAN	17AX	CMS	$A^0 b\bar{b}, A^0 \rightarrow \mu^+ \mu^-$
		3	AAD	16AX	ATLS	$H_2^0 \rightarrow ZZ$
		4	KHACHATRYAN	16P	CMS	$H_2^0 \rightarrow H^0 H^0, A^0 \rightarrow ZH^0$
		5	KHACHATRYAN	16W	CMS	$A^0 b\bar{b}, A^0 \rightarrow \tau^+ \tau^-$
		6	KHACHATRYAN	16Z	CMS	$H_2^0 \rightarrow ZA^0$ or $A^0 \rightarrow ZH_2^0$
		7	AAD	15BK	ATLS	$H_2^0 \rightarrow H^0 H^0$
		8	AAD	15S	ATLS	$A^0 \rightarrow ZH^0$
		9	KHACHATRYAN	15BB	CMS	$H_2^0, A^0 \rightarrow \gamma\gamma$
		10	KHACHATRYAN	15N	CMS	$A^0 \rightarrow ZH^0$
		11	AAD	14M	ATLS	$H_2^0 \rightarrow H^\pm W^\mp \rightarrow$ $H^0 W^\pm W^\mp, H^0 \rightarrow b\bar{b}$
		12	KHACHATRYAN	14Q	CMS	$H_2^0 \rightarrow H^0 H^0, A^0 \rightarrow ZH^0$
		13	AALTONEN	09AR	CDF	$p\bar{p} \rightarrow H_{1,2}^0/A^0 + X,$ $H_{1,2}^0/A^0 \rightarrow \tau^+ \tau^-$
none 1–55	95	14	ABBIENDI	05A	OPAL	H_1^0 , Type II model
>110.6	95	15	ABDALLAH	05D	DLPH	$H^0 \rightarrow 2 \text{ jets}$
		16	ABDALLAH	04O	DLPH	$Z \rightarrow f\bar{f}H$
		17	ABDALLAH	04O	DLPH	$e^+e^- \rightarrow H^0 Z, H^0 A^0$
		18	ABBIENDI	02D	OPAL	$e^+e^- \rightarrow b\bar{b}H$
none 1–44	95	19	ABBIENDI	01E	OPAL	H_1^0 , Type-II model
> 68.0	95	20	ABBIENDI	99E	OPAL	$\tan\beta > 1$
		21	ABREU	95H	DLPH	$Z \rightarrow H^0 Z^*, H^0 A^0$
		22	PICH	92	RVUE	Very light Higgs

¹ AABOUD 17AN search for production of a heavy H_2^0 and/or A^0 decaying to $t\bar{t}$ in 20.3 fb^{-1} of pp collisions at $E_{\text{cm}} = 8$ TeV. See their Fig. 3 and Table III for excluded parameter regions in Type II Two-Higgs-Doublet-Models.

² SIRUNYAN 17AX search for $A^0 b\bar{b}$ production followed by the decay $A^0 \rightarrow \mu^+ \mu^-$ in 19.7 fb^{-1} of pp collisions at $E_{\text{cm}} = 8$ TeV. Limits are set in the range $m_{A^0} = 25\text{--}60$ GeV. See their Fig. 5 for upper limits on $\sigma(A^0 b\bar{b}) \cdot \text{B}(A^0 \rightarrow \mu^+ \mu^-)$.

³ AAD 16AX search for production of a heavy H^0 state decaying to ZZ in the final states $\ell^+ \ell^- \ell^+ \ell^-, \ell^+ \ell^- \nu\bar{\nu}, \ell^+ \ell^- q\bar{q}$, and $\nu\bar{\nu} q\bar{q}$ in 20.3 fb^{-1} of pp collisions at $E_{\text{cm}} = 8$ TeV. See their Figs. 13 and 14 for excluded parameter regions in Type I and II models.

⁴ KHACHATRYAN 16P search for gluon fusion production of an H_2^0 decaying to $H^0 H^0 \rightarrow b\bar{b}\tau^+\tau^-$ and an A^0 decaying to $ZH^0 \rightarrow \ell^+ \ell^- \tau^+ \tau^-$ in 19.7 fb^{-1} of pp collisions at $E_{\text{cm}} = 8$ TeV. See their Fig. 11 for limits on $\tan\beta$ for $m_{A^0} = 230\text{--}350$ GeV.

⁵ KHACHATRYAN 16W search for $A^0 b\bar{b}$ production followed by the decay $A^0 \rightarrow \tau^+ \tau^-$ in 19.7 fb^{-1} of pp collisions at $E_{\text{cm}} = 8$ TeV. See their Fig. 3 for upper limits on $\sigma(A^0 b\bar{b}) \cdot \text{B}(A^0 \rightarrow \tau^+ \tau^-)$.

⁶ KHACHATRYAN 16Z search for $H_2^0 \rightarrow ZA^0$ followed by $A^0 \rightarrow b\bar{b}$ or $\tau^+ \tau^-$, and $A^0 \rightarrow ZH_2^0$ followed by $H_2^0 \rightarrow b\bar{b}$ or $\tau^+ \tau^-$, in 19.8 fb^{-1} of pp collisions at $E_{\text{cm}} = 8$ TeV. See their Fig. 4 for cross section limits and Fig. 5 for excluded region in the parameter space.

⁷ AAD 15BK search for production of a heavy H_2^0 decaying to $H^0 H^0$ in the final state $b\bar{b}b\bar{b}$ in 19.5 fb^{-1} of pp collisions at $E_{\text{cm}} = 8$ TeV. See their Figs. 15–18 for excluded regions in the parameter space.

- ⁸ AAD 15S search for production of A^0 decaying to $ZH^0 \rightarrow \ell^+ \ell^- b\bar{b}, \nu\bar{\nu} b\bar{b}$ and $\ell^+ \ell^- \tau^+ \tau^-$ in 20.3 fb^{-1} of pp collisions at $E_{\text{cm}} = 8 \text{ TeV}$. See their Figs. 4 and 5 for excluded regions in the parameter space.
- ⁹ KHACHATRYAN 15BB search for $H_2^0, A^0 \rightarrow \gamma\gamma$ in 19.7 fb^{-1} of pp collisions at $E_{\text{cm}} = 8 \text{ TeV}$. See their Fig. 10 for excluded regions in the two-Higgs-doublet model parameter space.
- ¹⁰ KHACHATRYAN 15N search for production of A^0 decaying to $ZH^0 \rightarrow \ell^+ \ell^- b\bar{b}$ in 19.7 fb^{-1} of pp collisions at $E_{\text{cm}} = 8 \text{ TeV}$. See their Fig. 5 for excluded regions in the $\tan\beta - \cos(\beta - \alpha)$ plane for $m_{A^0} = 300 \text{ GeV}$.
- ¹¹ 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 $b\bar{b}$ in 20.3 fb^{-1} of pp collisions at $E_{\text{cm}} = 8 \text{ TeV}$. See their Table IV for limits in a two-Higgs-doublet model for $m_{H_2^0} = 325\text{--}1025 \text{ GeV}$ and $m_{H^\pm} = 225\text{--}825 \text{ GeV}$.
- ¹² KHACHATRYAN 14Q search for $H_2^0 \rightarrow H^0 H^0$ and $A^0 \rightarrow ZH^0$ in 19.5 fb^{-1} of pp collisions at $E_{\text{cm}} = 8 \text{ TeV}$. See their Figs. 4 and 5 for limits on cross section times branching ratio for $m_{H_2^0, A^0} = 260\text{--}360 \text{ GeV}$ and their Figs. 7–9 for limits in two-Higgs-doublet models.
- ¹³ AALTONEN 09AR search for Higgs bosons decaying to $\tau^+ \tau^-$ in two doublet models in 1.8 fb^{-1} of $p\bar{p}$ collisions at $E_{\text{cm}} = 1.96 \text{ TeV}$. See their Fig. 2 for the limit on $\sigma \cdot \text{B}(H_{1,2}^0/A^0 \rightarrow \tau^+ \tau^-)$ for different Higgs masses, and see their Fig. 3 for the excluded region in the MSSM parameter space.
- ¹⁴ ABBIENDI 05A search for $e^+ e^- \rightarrow H_1^0 A^0$ in general Type-II two-doublet models, with decays $H_1^0, A^0 \rightarrow q\bar{q}, g g, \tau^+ \tau^-$, and $H_1^0 \rightarrow A^0 A^0$.
- ¹⁵ 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 $g g$. The limit is for SM $H^0 Z$ production cross section with $\text{B}(H^0 \rightarrow jj) = 1$.
- ¹⁶ ABDALLAH 04O search for $Z \rightarrow b\bar{b}H^0, b\bar{b}A^0, \tau^+ \tau^- H^0$ and $\tau^+ \tau^- A^0$ in the final states $4b, b\bar{b}\tau^+ \tau^-$, and 4τ . See paper for limits on Yukawa couplings.
- ¹⁷ ABDALLAH 04O search for $e^+ e^- \rightarrow H^0 Z$ and $H^0 A^0$, with H^0, A^0 decaying to $b\bar{b}, \tau^+ \tau^-$, or $H^0 \rightarrow A^0 A^0$ at $E_{\text{cm}} = 189\text{--}208 \text{ GeV}$. See paper for limits on couplings.
- ¹⁸ ABBIENDI 02D search for $Z \rightarrow b\bar{b}H_1^0$ and $b\bar{b}A^0$ with $H_1^0/A^0 \rightarrow \tau^+ \tau^-$, in the range $4 < m_H < 12 \text{ GeV}$. See their Fig. 8 for limits on the Yukawa coupling.
- ¹⁹ ABBIENDI 01E search for neutral Higgs bosons in general Type-II two-doublet models, at $E_{\text{cm}} \leq 189 \text{ GeV}$. In addition to usual final states, the decays $H_1^0, A^0 \rightarrow q\bar{q}, g g$ are searched for. See their Figs. 15,16 for excluded regions.
- ²⁰ ABBIENDI 99E search for $e^+ e^- \rightarrow H^0 A^0$ and $H^0 Z$ at $E_{\text{cm}} = 183 \text{ GeV}$. 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.
- ²¹ 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 $m_{H^0} + m_{A^0} \lesssim 87 \text{ GeV}, m_{H^0} < 47 \text{ GeV}$ is excluded at 95% CL.
- ²² 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 π^\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. • • •
none	100–113	95 1 AALTONEN 13K	CDF	$H^0 \rightarrow WW^{(*)}$
none	100–116	95 2 AALTONEN 13L	CDF	$H^0 \rightarrow \gamma\gamma, WW^*, ZZ^*$
none	100–113	95 3 AALTONEN 13M	TEVA	$H^0 \rightarrow \gamma\gamma, WW^*, ZZ^*$
none	100–113	95 4 ABAZOV 13G	D0	$H^0 \rightarrow WW^{(*)}$
none	100–114	95 5 ABAZOV 13H	D0	$H^0 \rightarrow \gamma\gamma$
none	110–147	95 6 ABAZOV 13I	D0	$H^0 \rightarrow WW^{(*)}$
none	110–118, 119.5–121	95 7 ABAZOV 13J	D0	$H^0 \rightarrow WW^{(*)}, ZZ^{(*)}$
none	110–114	95 8 ABAZOV 13L	D0	$H^0 \rightarrow \gamma\gamma, WW^*, ZZ^*$
none	110–118, 119.5–121	95 9 CHATRCHYAN 13AL	CMS	$H^0 \rightarrow \gamma\gamma$
none	100–114	95 10 AAD 12N	ATLS	$H^0 \rightarrow \gamma\gamma$
none	100–114	95 11 AALTONEN 12AN	CDF	$H^0 \rightarrow \gamma\gamma$
none	110–194	95 12 CHATRCHYAN 12AO	CMS	$H^0 \rightarrow \gamma\gamma, WW^{(*)}, ZZ^{(*)}$
none	70–106	95 13 AALTONEN 09AB	CDF	$H^0 \rightarrow \gamma\gamma$
none	70–100	95 14 ABAZOV 08U	D0	$H^0 \rightarrow \gamma\gamma$
>105.8	95	15 SCHAEEL 07	ALEP	$e^+e^- \rightarrow H^0 Z, H^0 \rightarrow WW^*$
>104.1	95	16,17 ABDALLAH 04L	DLPH	$e^+e^- \rightarrow H^0 Z, H^0 \rightarrow \gamma\gamma$
>107	95	18 ACHARD 03C	L3	$H^0 \rightarrow WW^*, ZZ^*, \gamma\gamma$
>105.5	95	16,19 ABBIENDI 02F	OPAL	$H^0 \rightarrow \gamma\gamma$
>105.4	95	20 ACHARD 02C	L3	$H^0 \rightarrow \gamma\gamma$
none	60–82	95 21 AFFOLDER 01H	CDF	$p\bar{p} \rightarrow H^0 W/Z, H^0 \rightarrow \gamma\gamma$
> 94.9	95	22 ACCIARRI 00S	L3	$e^+e^- \rightarrow H^0 Z, H^0 \rightarrow \gamma\gamma$
>100.7	95	23 BARATE 00L	ALEP	$e^+e^- \rightarrow H^0 Z, H^0 \rightarrow \gamma\gamma$
> 96.2	95	24 ABBIENDI 99O	OPAL	$e^+e^- \rightarrow H^0 Z, H^0 \rightarrow \gamma\gamma$
> 78.5	95	25 ABBOTT 99B	D0	$p\bar{p} \rightarrow H^0 W/Z, H^0 \rightarrow \gamma\gamma$
		26 ABREU 99P	DLPH	$e^+e^- \rightarrow H^0\gamma$ and/or $H^0 \rightarrow \gamma\gamma$

¹ AALTONEN 13K search for $H^0 \rightarrow WW^{(*)}$ in 9.7 fb^{-1} of $p\bar{p}$ collisions at $E_{\text{cm}} = 1.96$ 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 $m_{H^0} = 110\text{--}200$ GeV at 95% CL.

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

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

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

⁵ ABAZOV 13H search for $H^0 \rightarrow \gamma\gamma$ in 9.6 fb^{-1} of $p\bar{p}$ collisions at $E_{\text{cm}} = 1.96$ 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 $p\bar{p}$ collisions at $E_{\text{cm}} = 1.96$ TeV. The search is sensitive to WH^0, ZH^0 and vector-boson fusion Higgs production with $H^0 \rightarrow WW^{(*)}$. A limit on cross section times branching ratio which corresponds to (8–30) times the expected cross section is given in the range $m_{H^0} = 100\text{--}200$ 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 $8.6\text{--}9.7\text{ fb}^{-1}$ of $p\bar{p}$ collisions at $E_{\text{cm}} = 1.96\text{ TeV}$. The search is sensitive to WH^0 , ZH^0 production with $H^0 \rightarrow WW^{(*)}$, $ZZ^{(*)}$, 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 $m_{H^0} = 100\text{--}200\text{ GeV}$ at 95% CL.
- ⁸ ABAZOV 13L combine all D0 results with up to 9.7 fb^{-1} of $p\bar{p}$ collisions at $E_{\text{cm}} = 1.96\text{ TeV}$.
- ⁹ CHATRCHYAN 13AL search for $H^0 \rightarrow \gamma\gamma$ in 5.1 fb^{-1} and 5.3 fb^{-1} of pp collisions at $E_{\text{cm}} = 7$ and 8 TeV .
- ¹⁰ AAD 12N search for $H^0 \rightarrow \gamma\gamma$ with 4.9 fb^{-1} of pp collisions at $E_{\text{cm}} = 7\text{ TeV}$ in the mass range $m_{H^0} = 110\text{--}150\text{ GeV}$.
- ¹¹ AALTONEN 12AN search for $H^0 \rightarrow \gamma\gamma$ with 10 fb^{-1} of $p\bar{p}$ collisions at $E_{\text{cm}} = 1.96\text{ TeV}$ in the mass range $m_{H^0} = 100\text{--}150\text{ GeV}$.
- ¹² CHATRCHYAN 12A0 use data from CHATRCHYAN 12G, CHATRCHYAN 12E, CHATRCHYAN 12H, CHATRCHYAN 12I, CHATRCHYAN 12D, and CHATRCHYAN 12C.
- ¹³ AALTONEN 09AB search for $H^0 \rightarrow \gamma\gamma$ in 3.0 fb^{-1} of $p\bar{p}$ collisions at $E_{\text{cm}} = 1.96\text{ TeV}$ in the mass range $m_{H^0} = 70\text{--}150\text{ GeV}$. Associated H^0W , H^0Z production and WW , ZZ fusion are considered.
- ¹⁴ ABAZOV 08U search for $H^0 \rightarrow \gamma\gamma$ in $p\bar{p}$ collisions at $E_{\text{cm}} = 1.96\text{ TeV}$ in the mass range $m_{H^0} = 70\text{--}150\text{ GeV}$. Associated H^0W , H^0Z production and WW , ZZ fusion are considered. See their Tab. 1 for the limit on $\sigma \cdot B(H^0 \rightarrow \gamma\gamma)$, and see their Fig. 3 for the excluded region in the $m_{H^0} - B(H^0 \rightarrow \gamma\gamma)$ plane.
- ¹⁵ SCHAEEL 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 $Z \rightarrow q\bar{q}$, $\ell^+\ell^-$, or $\nu\bar{\nu}$, at $E_{\text{cm}} \leq 209\text{ GeV}$. The limit is for a H^0 with SM production cross section.
- ¹⁷ Updates ABREU 01F.
- ¹⁸ ACHARD 03C search for $e^+e^- \rightarrow ZH^0$ followed by $H^0 \rightarrow WW^*$ or ZZ^* at $E_{\text{cm}} = 200\text{--}209\text{ GeV}$ and combine with the ACHARD 02C result. The limit is for a H^0 with SM production cross section. For $B(H^0 \rightarrow WW^*) + B(H^0 \rightarrow ZZ^*) = 1$, $m_{H^0} > 108.1\text{ GeV}$ is obtained. See fig. 6 for the limits under different BR assumptions.
- ¹⁹ For $B(H^0 \rightarrow \gamma\gamma) = 1$, $m_{H^0} > 117\text{ GeV}$ is obtained.
- ²⁰ ACHARD 02C search for associated production of a $\gamma\gamma$ resonance with a Z boson, followed by $Z \rightarrow q\bar{q}$, $\ell^+\ell^-$, or $\nu\bar{\nu}$, at $E_{\text{cm}} \leq 209\text{ GeV}$. The limit is for a H^0 with SM production cross section. For $B(H^0 \rightarrow \gamma\gamma) = 1$, $m_{H^0} > 114\text{ GeV}$ 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 $B(H^0 \rightarrow \gamma\gamma) < 1$.
- ²² ACCIARRI 00S search for associated production of a $\gamma\gamma$ resonance with a $q\bar{q}$, $\nu\bar{\nu}$, or $\ell^+\ell^-$ pair in e^+e^- collisions at $E_{\text{cm}} = 189\text{ GeV}$. The limit is for a H^0 with SM production cross section. For $B(H^0 \rightarrow \gamma\gamma) = 1$, $m_{H^0} > 98\text{ GeV}$ is obtained. See their Fig. 5 for limits on $B(H \rightarrow \gamma\gamma) \cdot \sigma(e^+e^- \rightarrow Hf\bar{f}) / \sigma(e^+e^- \rightarrow Hf\bar{f})$ (SM).
- ²³ BARATE 00L search for associated production of a $\gamma\gamma$ resonance with a $q\bar{q}$, $\nu\bar{\nu}$, or $\ell^+\ell^-$ pair in e^+e^- collisions at $E_{\text{cm}} = 88\text{--}202\text{ GeV}$. The limit is for a H^0 with SM production cross section. For $B(H^0 \rightarrow \gamma\gamma) = 1$, $m_{H^0} > 109\text{ GeV}$ is obtained. See their Fig. 3 for limits on $B(H \rightarrow \gamma\gamma) \cdot \sigma(e^+e^- \rightarrow Hf\bar{f}) / \sigma(e^+e^- \rightarrow Hf\bar{f})$ (SM).

- ²⁴ **ABBIENDI 990** search for associated production of a $\gamma\gamma$ resonance with a $q\bar{q}$, $\nu\bar{\nu}$, 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 $\sigma(e^+e^- \rightarrow H^0 Z^0) \times B(H^0 \rightarrow \gamma\gamma) \times B(X^0 \rightarrow f\bar{f})$ 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 $\sigma(H^0 + Z/W) \cdot B(H^0 \rightarrow \gamma\gamma) = 0.80\text{--}0.34$ pb are obtained in the mass range $m_{H^0} = 65\text{--}150$ GeV.
- ²⁶ **ABREU 99P** search for $e^+e^- \rightarrow H^0\gamma$ with $H^0 \rightarrow b\bar{b}$ or $\gamma\gamma$, and $e^+e^- \rightarrow H^0 q\bar{q}$ with $H^0 \rightarrow \gamma\gamma$. 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
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• • • We do not use the following data for averages, fits, limits, etc. • • •

		1 AAD	15BD ATLS	$pp \rightarrow H^0 WX, H^0 ZX$
		2 AAD	15BH ATLS	jet + missing E_T
		3 AAD	14BA ATLS	secondary vertex
		4 AAD	14O ATLS	$pp \rightarrow H^0 ZX$
		5 CHATRCHYAN	14B CMS	$pp \rightarrow H^0 ZX, qqH^0 X$
		6 AAD	13AG ATLS	secondary vertex
		7 AAD	13AT ATLS	electron jets
		8 CHATRCHYAN	13BJ CMS	
		9 AAD	12AQ ATLS	secondary vertex
		10 AALTONEN	12AB CDF	secondary vertex
		11 AALTONEN	12U CDF	secondary vertex
>108.2	95	12 ABBIENDI	10 OPAL	
		13 ABBIENDI	07 OPAL	large width
>112.3	95	14 ACHARD	05 L3	
>112.1	95	14 ABDALLAH	04B DLPH	
>114.1	95	14 HEISTER	02 ALEP	$E_{\text{cm}} \leq 209$ GeV
>106.4	95	14 BARATE	01C ALEP	$E_{\text{cm}} \leq 202$ GeV
> 89.2	95	15 ACCIARRI	00M L3	

¹ AAD 15BD search for $pp \rightarrow H^0 WX$ and $pp \rightarrow H^0 ZX$ with W or Z decaying hadronically and H^0 decaying to invisible final states in 20.3 fb^{-1} at $E_{\text{cm}} = 8 \text{ TeV}$. See their Fig. 6 for a limit on the cross section times branching ratio for $m_{H^0} = 115\text{--}300$ GeV.

² AAD 15BH search for events with a jet and missing E_T in 20.3 fb^{-1} of pp collisions at $E_{\text{cm}} = 8 \text{ TeV}$. Limits on $\sigma(H^0) B(H^0 \rightarrow \text{invisible}) < (44\text{--}10) \text{ pb}$ (95%CL) is given for $m_{H^0} = 115\text{--}300$ GeV.

³ AAD 14BA search for H^0 production in the decay mode $H^0 \rightarrow X^0 X^0$, 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 $E_{\text{cm}} = 8 \text{ TeV}$. See their Figs. 15 and 16 for limits on cross section times branching ratio.

⁴ AAD 14O search for $pp \rightarrow H^0 ZX$, $Z \rightarrow \ell\ell$, with H^0 decaying to invisible final states in 4.5 fb^{-1} at $E_{\text{cm}} = 7 \text{ TeV}$ and 20.3 fb^{-1} at $E_{\text{cm}} = 8 \text{ TeV}$. See their Fig. 3 for a limit on the cross section times branching ratio for $m_{H^0} = 110\text{--}400$ GeV.

- 5 CHATRCHYAN 14B search for $pp \rightarrow H^0 Z X$, $Z \rightarrow \ell\ell$ and $Z \rightarrow b\bar{b}$, and also $pp \rightarrow qqH^0 X$ with H^0 decaying to invisible final states using data at $E_{\text{cm}} = 7$ and 8 TeV. See their Figs. 10, 11 for limits on the cross section times branching ratio for $m_{H^0} = 100\text{--}400$ GeV.
- 6 AAD 13AG search for H^0 production in the decay mode $H^0 \rightarrow X^0 X^0$, where X^0 is a long-lived particle which decays to $\mu^+ \mu^- X'^0$, in 1.9 fb^{-1} of pp collisions at $E_{\text{cm}} = 7$ TeV. See their Fig. 7 for limits on cross section times branching ratio.
- 7 AAD 13AT search for H^0 production in the decay $H^0 \rightarrow X^0 X^0$, where X^0 eventually decays to clusters of collimated $e^+ e^-$ pairs, in 2.04 fb^{-1} of pp collisions at $E_{\text{cm}} = 7$ TeV. See their Fig. 3 for limits on cross section times branching ratio.
- 8 CHATRCHYAN 13BJ search for H^0 production in the decay chain $H^0 \rightarrow X^0 X^0$, $X^0 \rightarrow \mu^+ \mu^- X'^0$ in 5.3 fb^{-1} of pp collisions at $E_{\text{cm}} = 7$ TeV. See their Fig. 2 for limits on cross section times branching ratio.
- 9 AAD 12AQ search for H^0 production in the decay mode $H^0 \rightarrow X^0 X^0$, where X^0 is a long-lived particle which decays mainly to $b\bar{b}$ in the muon detector, in 1.94 fb^{-1} of pp collisions at $E_{\text{cm}} = 7$ 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.
- 10 AALTONEN 12AB search for H^0 production in the decay $H^0 \rightarrow X^0 X^0$, where X^0 eventually decays to clusters of collimated $\ell^+ \ell^-$ pairs, in 5.1 fb^{-1} of $p\bar{p}$ collisions at $E_{\text{cm}} = 1.96$ TeV. Cross section limits are provided for a benchmark MSSM model incorporating the parameters given in Table VI.
- 11 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 $b\bar{b}$, in 3.2 fb^{-1} of $p\bar{p}$ collisions at $E_{\text{cm}} = 1.96$ TeV. See their Figs. 9 and 10 for limits on cross section times branching ratio for $m_{H^0} = (130\text{--}170)$ GeV, $m_{X^0} = 20, 40$ GeV.
- 12 ABBIENDI 10 search for $e^+ e^- \rightarrow H^0 Z$ with H^0 decaying invisibly. The limit assumes SM production cross section and $B(H^0 \rightarrow \text{invisible}) = 1$.
- 13 ABBIENDI 07 search for $e^+ e^- \rightarrow H^0 Z$ with $Z \rightarrow q\bar{q}$ and H^0 decaying to invisible final states. The H^0 width is varied between 1 GeV and 3 TeV. A limit $\sigma \cdot B(H^0 \rightarrow \text{invisible}) < (0.07\text{--}0.57)$ pb (95%CL) is obtained at $E_{\text{cm}} = 206$ GeV for $m_{H^0} = 60\text{--}114$ GeV.
- 14 Search for $e^+ e^- \rightarrow H^0 Z$ with H^0 decaying invisibly. The limit assumes SM production cross section and $B(H^0 \rightarrow \text{invisible}) = 1$.
- 15 ACCIARRI 00M search for $e^+ e^- \rightarrow ZH^0$ with H^0 decaying invisibly at $E_{\text{cm}} = 183\text{--}189$ GeV. The limit assumes SM production cross section and $B(H^0 \rightarrow \text{invisible}) = 1$. 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)	DOCUMENT ID	TECN	COMMENT
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• • • We do not use the following data for averages, fits, limits, etc. • • •

1	KHACHATRY...17AZ	CMS	$H^0 \rightarrow A^0 A^0$
2	ABLIKIM 16E	BES3	$J/\psi \rightarrow A^0 \gamma$
3	KHACHATRY...16F	CMS	$H^0 \rightarrow A^0 A^0$
4	LEES 15H	BABR	$\Upsilon(1S) \rightarrow A^0 \gamma$
5	LEES 13C	BABR	$\Upsilon(1S) \rightarrow A^0 \gamma$
6	LEES 13L	BABR	$\Upsilon(1S) \rightarrow A^0 \gamma$
7	LEES 13R	BABR	$\Upsilon(1S) \rightarrow A^0 \gamma$
8	ABLIKIM 12	BES3	$J/\psi \rightarrow A^0 \gamma$
9	CHATRCHYAN 12V	CMS	$A^0 \rightarrow \mu^+ \mu^-$
10	AALTONEN 11P	CDF	$t \rightarrow bH^+$, $H^+ \rightarrow W^+ A^0$
11,12	ABOUZAID 11A	KTEV	$K_L \rightarrow \pi^0 \pi^0 A^0$, $A^0 \rightarrow \mu^+ \mu^-$

13	DEL-AMO-SA..11J	BABR	$\Upsilon(1S) \rightarrow A^0 \gamma$
14	LEES	11H BABR	$\Upsilon(2S, 3S) \rightarrow A^0 \gamma$
15	ANDREAS	10 RVUE	
12,16	HYUN	10 BELL	$B^0 \rightarrow K^{*0} A^0, A^0 \rightarrow \mu^+ \mu^-$
12,17	HYUN	10 BELL	$B^0 \rightarrow \rho^0 A^0, A^0 \rightarrow \mu^+ \mu^-$
18	AUBERT	09P BABR	$\Upsilon(3S) \rightarrow A^0 \gamma$
19	AUBERT	09Z BABR	$\Upsilon(2S) \rightarrow A^0 \gamma$
20	AUBERT	09Z BABR	$\Upsilon(3S) \rightarrow A^0 \gamma$
12,21	TUNG	09 K391	$K_L \rightarrow \pi^0 \pi^0 A^0, A^0 \rightarrow \gamma \gamma$
22	LOVE	08 CLEO	$\Upsilon(1S) \rightarrow A^0 \gamma$
23	BESSON	07 CLEO	$\Upsilon(1S) \rightarrow \eta_b \gamma$
24	PARK	05 HYCP	$\Sigma^+ \rightarrow p A^0, A^0 \rightarrow \mu^+ \mu^-$
25	BALEST	95 CLE2	$\Upsilon(1S) \rightarrow A^0 \gamma$
26	ANTREASYAN 90C	CBAL	$\Upsilon(1S) \rightarrow A^0 \gamma$

¹ KHACHATRYAN 17AZ search for the decay $H^0 \rightarrow A^0 A^0 \rightarrow \tau^+ \tau^- \tau^+ \tau^-, \mu^+ \mu^- b \bar{b}$, and $\mu^+ \mu^- \tau^+ \tau^-$ in 19.7 fb^{-1} of pp collisions at $E_{\text{cm}} = 8 \text{ TeV}$. See their Figs. 4, 5, and 6 for cross section limits in the range $m_{A^0} = 5\text{--}62.5 \text{ GeV}$. See also their Figs. 7, 8, and 9 for interpretation of the data in terms of models with two Higgs doublets and a singlet.

² ABLIKIM 16E search for the process $J/\psi \rightarrow A^0 \gamma$ with A^0 decaying to $\mu^+ \mu^-$ and give limits on $B(J/\psi \rightarrow A^0 \gamma) \cdot B(A^0 \rightarrow \mu^+ \mu^-)$ in the range $2.8 \times 10^{-8}\text{--}5.0 \times 10^{-6}$ (90% CL) for $0.212 \leq m_{A^0} \leq 3.0 \text{ GeV}$. See their Fig. 5.

³ KHACHATRYAN 16F search for the decay $H^0 \rightarrow A^0 A^0 \rightarrow \tau^+ \tau^- \tau^+ \tau^-$ in 19.7 fb^{-1} of pp collisions at $E_{\text{cm}} = 8 \text{ TeV}$. See their Fig. 8 for cross section limits for $m_{A^0} = 4\text{--}8 \text{ GeV}$.

⁴ LEES 15H search for the process $\Upsilon(2S) \rightarrow \Upsilon(1S) \pi^+ \pi^- \rightarrow A^0 \gamma \pi^+ \pi^-$ with A^0 decaying to $c \bar{c}$ and give limits on $B(\Upsilon(1S) \rightarrow A^0 \gamma) \cdot B(A^0 \rightarrow c \bar{c})$ in the range $7.4 \times 10^{-5}\text{--}2.4 \times 10^{-3}$ (90% CL) for $4.00 \leq m_{A^0} \leq 8.95$ and $9.10 \leq m_{A^0} \leq 9.25 \text{ GeV}$. See their Fig. 6.

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

⁶ 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 $s \bar{s}$ and give limits on $B(\Upsilon(1S) \rightarrow A^0 \gamma) \cdot B(A^0 \rightarrow g g)$ between 1×10^{-6} and 2×10^{-2} (90% CL) for $0.5 \leq m_{A^0} \leq 9.0 \text{ GeV}$, and $B(\Upsilon(1S) \rightarrow A^0 \gamma) \cdot B(A^0 \rightarrow s \bar{s})$ between 4×10^{-6} and 1×10^{-3} (90% CL) for $1.5 \leq m_{A^0} \leq 9.0 \text{ GeV}$. See their Fig. 4.

⁷ 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 $B(\Upsilon(1S) \rightarrow A^0 \gamma) \cdot B(A^0 \rightarrow \tau^+ \tau^-)$ in the range $0.9\text{--}13 \times 10^{-5}$ (90% CL) for $3.6 \leq m_{A^0} \leq 9.2 \text{ GeV}$. See their Fig. 4 for limits on the $b\text{--}A^0$ Yukawa coupling derived by combining this result with AUBERT 09P.

⁸ ABLIKIM 12 searches for the process $\psi(3686) \rightarrow \pi \pi J/\psi, J/\psi \rightarrow A^0 \gamma$ with A^0 decaying to $\mu^+ \mu^-$. It gives mass dependent limits on $B(J/\psi \rightarrow A^0 \gamma) \cdot B(A^0 \rightarrow \mu^+ \mu^-)$ in the range $4 \times 10^{-7}\text{--}2.1 \times 10^{-5}$ (90% C.L.) for $0.212 \leq m_{A^0} \leq 3.0 \text{ GeV}$. See their Fig. 2.

⁹ CHATRCHYAN 12V search for A^0 production in the decay $A^0 \rightarrow \mu^+ \mu^-$ with 1.3 fb^{-1} of pp collisions at $E_{\text{cm}} = 7 \text{ TeV}$. A limit on $\sigma(A^0) \cdot B(A^0 \rightarrow \mu^+ \mu^-)$ in the range (1.5–7.5) pb is given for $m_{A^0} = (5.5\text{--}8.7)$ and (11.5–14) GeV at 95% CL.

- ¹⁰ AALTONEN 11P search in 2.7 fb^{-1} of $p\bar{p}$ collisions at $E_{\text{cm}} = 1.96 \text{ TeV}$ 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 $90 < m_{H^+} < 160 \text{ GeV}$.
- ¹¹ ABOUZAIID 11A search for the decay chain $K_L \rightarrow \pi^0\pi^0A^0$, $A^0 \rightarrow \mu^+\mu^-$ and give a limit $B(K_L \rightarrow \pi^0\pi^0A^0) \cdot B(A^0 \rightarrow \mu^+\mu^-) < 1.0 \times 10^{-10}$ at 90% CL for $m_{A^0} = 214.3 \text{ MeV}$.
- ¹² The search was motivated by PARK 05.
- ¹³ 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 $B(\Upsilon(1S) \rightarrow A^0\gamma) \cdot B(A^0 \rightarrow \text{invisible})$ in the range $(1.9\text{--}4.5) \times 10^{-6}$ (90% CL) for $0 \leq m_{A^0} \leq 8.0 \text{ GeV}$, and $(2.7\text{--}37) \times 10^{-6}$ for $8.0 \leq m_{A^0} \leq 9.2 \text{ GeV}$.
- ¹⁴ LEES 11H search for the process $\Upsilon(2S, 3S) \rightarrow A^0\gamma$ with A^0 decaying hadronically and give limits on $B(\Upsilon(2S, 3S) \rightarrow A^0\gamma) \cdot B(A^0 \rightarrow \text{hadrons})$ in the range $1 \times 10^{-6}\text{--}8 \times 10^{-5}$ (90% CL) for $0.3 < m_{A^0} < 7 \text{ GeV}$. The decay rates for $\Upsilon(2S)$ and $\Upsilon(3S)$ are assumed to be equal up to the phase space factor. See their Fig. 5.
- ¹⁵ 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.
- ¹⁶ HYUN 10 search for the decay chain $B^0 \rightarrow K^{*0}A^0$, $A^0 \rightarrow \mu^+\mu^-$ and give a limit on $B(B^0 \rightarrow K^{*0}A^0) \cdot B(A^0 \rightarrow \mu^+\mu^-)$ in the range $(2.26\text{--}5.53) \times 10^{-8}$ at 90%CL for $m_{A^0} = 212\text{--}300 \text{ MeV}$. The limit for $m_{A^0} = 214.3 \text{ MeV}$ is 2.26×10^{-8} .
- ¹⁷ HYUN 10 search for the decay chain $B^0 \rightarrow \rho^0A^0$, $A^0 \rightarrow \mu^+\mu^-$ and give a limit on $B(B^0 \rightarrow \rho^0A^0) \cdot B(A^0 \rightarrow \mu^+\mu^-)$ in the range $(1.73\text{--}4.51) \times 10^{-8}$ at 90%CL for $m_{A^0} = 212\text{--}300 \text{ MeV}$. The limit for $m_{A^0} = 214.3 \text{ MeV}$ is 1.73×10^{-8} .
- ¹⁸ 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 $9.61 < m_{A^0} < 10.10 \text{ GeV}$, and give limits on $B(\Upsilon(3S) \rightarrow A^0\gamma) \cdot B(A^0 \rightarrow \tau^+\tau^-)$ in the range $(1.5\text{--}16) \times 10^{-5}$ (90% CL).
- ¹⁹ AUBERT 09Z search for the process $\Upsilon(2S) \rightarrow A^0\gamma$ with $A^0 \rightarrow \mu^+\mu^-$ for $0.212 < m_{A^0} < 9.3 \text{ GeV}$ and give limits on $B(\Upsilon(2S) \rightarrow A^0\gamma) \cdot B(A^0 \rightarrow \mu^+\mu^-)$ in the range $(0.3\text{--}8) \times 10^{-6}$ (90% CL).
- ²⁰ AUBERT 09Z search for the process $\Upsilon(3S) \rightarrow A^0\gamma$ with $A^0 \rightarrow \mu^+\mu^-$ for $0.212 < m_{A^0} < 9.3 \text{ GeV}$ and give limits on $B(\Upsilon(3S) \rightarrow A^0\gamma) \cdot B(A^0 \rightarrow \mu^+\mu^-)$ in the range $(0.3\text{--}5) \times 10^{-6}$ (90% CL).
- ²¹ 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 $B(K_L \rightarrow \pi^0\pi^0A^0) \cdot B(A^0 \rightarrow \gamma\gamma)$ in the range $(2.4\text{--}10.7) \times 10^{-7}$ at 90%CL for $m_{A^0} = 194.3\text{--}219.3 \text{ MeV}$. The limit for $m_{A^0} = 214.3 \text{ MeV}$ is 2.4×10^{-7} .
- ²² 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 $B(\Upsilon(1S) \rightarrow A^0\gamma) \cdot B(A^0 \rightarrow \ell^+\ell^-)$ in the range $10^{-6}\text{--}10^{-4}$ (90% CL) are given.
- ²³ 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.
- ²⁴ 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 $m_{A^0} = 214.3 \pm 0.5 \text{ MeV}$ and the branching fraction $B(\Sigma^+ \rightarrow pA^0) \cdot B(A^0 \rightarrow \mu^+\mu^-) = (3.1_{-1.9}^{+2.4} \pm 1.5) \times 10^{-8}$.

²⁵ BALEST 95 give limits $B(\Upsilon(1S) \rightarrow A^0 \gamma) \leq 1.5 \times 10^{-5}$ at 90% CL for $m_{A^0} < 5$ GeV.

The limit becomes $< 10^{-4}$ for $m_{A^0} < 7.7$ GeV.

²⁶ ANTREASYAN 90C give limits $B(\Upsilon(1S) \rightarrow A^0 \gamma) \leq 5.6 \times 10^{-5}$ at 90% CL for $m_{A^0} < 7.2$ GeV. A^0 is assumed not to decay in the detector.

Other Mass Limits

We use a symbol H_1^0 if mass < 125 GeV or H_2^0 if mass > 125 GeV. The notation H^0 is reserved for the 125 GeV particle.

VALUE (GeV)	CL%	DOCUMENT ID	TECN	COMMENT
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●				
		1 SIRUNYAN 18F CMS		$pp, 13$ TeV, $H_2^0 \rightarrow H^0 H^0$
		2 AABOUD 17 ATLS		$H_2^0 \rightarrow Z \gamma$
		3 AABOUD 17AW ATLS		$H_2^0 \rightarrow Z \gamma$
		4 KHACHATRY...17D CMS		$pp, 8, 13$ TeV, $H_2^0 \rightarrow Z \gamma$
		5 KHACHATRY...17R CMS		$H_2^0 \rightarrow \gamma \gamma$
		6 SIRUNYAN 17CN CMS		$pp, 8$ TeV, $H_2^0 \rightarrow H^0 H^0$
		7 SIRUNYAN 17Y CMS		$pp, 8, 13$ TeV, $H_2^0 \rightarrow Z \gamma$
		8 AABOUD 16AB ATLS		$H^0 \rightarrow A^0 A^0$
		9 AABOUD 16AE ATLS		$H_2^0 \rightarrow W^+ W^-, Z Z$
		10 AABOUD 16H ATLS		$H_2^0 \rightarrow \gamma \gamma$
		11 AABOUD 16I ATLS		$H_2^0 \rightarrow H^0 H^0$
		12 AAD 16AX ATLS		$H^0 \rightarrow Z Z$
		13 AAD 16C ATLS		$H^0 \rightarrow W^+ W^-$
		14 AAD 16L ATLS		$H^0 \rightarrow A^0 A^0$
		15 AAD 16L ATLS		$H_2^0 \rightarrow A^0 A^0$
		16 AALTONEN 16C CDF		$H_1^0 H^\pm \rightarrow H_1^0 H_1^0 W^*,$ $H_1^0 \rightarrow \gamma \gamma$
		17 KHACHATRY...16BG CMS		$H_2^0 \rightarrow H^0 H^0$
		18 KHACHATRY...16BQ CMS		$pp, 8$ TeV, $H_2^0 \rightarrow H^0 H^0$
		19 KHACHATRY...16F CMS		$H^0 \rightarrow H_1^0 H_1^0$
		20 KHACHATRY...16M CMS		$H_2^0 \rightarrow \gamma \gamma$
		21 KHACHATRY...16P CMS		$H_2^0 \rightarrow H^0 H^0$
		22 KHACHATRY...16P CMS		$A^0 \rightarrow Z H^0$
		23 AAD 15BK ATLS		$H_2^0 \rightarrow H^0 H^0$
		24 AAD 15BZ ATLS		$H^0 \rightarrow A^0 A^0$
		25 AAD 15BZ ATLS		$H_2^0 \rightarrow A^0 A^0$
		26 AAD 15CE ATLS		$H_2^0 \rightarrow H^0 H^0$
		27 AAD 15H ATLS		$H_2^0 \rightarrow H^0 H^0$
		28 AAD 15S ATLS		$A^0 \rightarrow Z H^0$
		29 KHACHATRY...15AW CMS		$H_2^0 \rightarrow W^+ W^-, Z Z$
		30 KHACHATRY...15BB CMS		$H^0 \rightarrow \gamma \gamma$
		31 KHACHATRY...15N CMS		$A^0 \rightarrow Z H^0$
		32 KHACHATRY...15O CMS		$A^0 \rightarrow Z H^0$
		33 KHACHATRY...15R CMS		$H_2^0 \rightarrow H^0 H^0$

		34	AAD	14AP	ATLS	$H^0 \rightarrow \gamma\gamma$
		35	AAD	14M	ATLS	$H_2^0 \rightarrow H^\pm W^\mp \rightarrow H^0 W^\pm W^\mp, H^0 \rightarrow b\bar{b}$
		36	CHATRCHYAN	14G	CMS	$H^0 \rightarrow W W^*$
		37	KHACHATRYAN	14P	CMS	$H^0 \rightarrow \gamma\gamma$
		38	AALTONEN	13P	CDF	$H^0 \rightarrow H^\pm W^\mp \rightarrow H^0 W^+ W^-$
		39	CHATRCHYAN	13BJ	CMS	$H^0 \rightarrow A^0 A^0$
		40	AALTONEN	11P	CDF	$t \rightarrow bH^+, H^+ \rightarrow W^+ A^0$
		41	ABBIENDI	10	OPAL	$H^0 \rightarrow \tilde{\chi}_1^0 \tilde{\chi}_2^0$
		42	SCHAEL	10	ALEP	$H^0 \rightarrow A^0 A^0$
		43	ABAZOV	09V	D0	$H^0 \rightarrow A^0 A^0$
none 3–63	95	44	ABBIENDI	05A	OPAL	A^0 , Type II model
>104	95	45	ABBIENDI	04K	OPAL	$H^0 \rightarrow 2$ jets
		46	ABDALLAH	04	DLPH	$H^0 VV$ couplings
>110.3	95	47	ACHARD	04B	L3	$H^0 \rightarrow 2$ jets
		48	ACHARD	04F	L3	Anomalous coupling
		49	ABBIENDI	03F	OPAL	$e^+ e^- \rightarrow H^0 Z, H^0 \rightarrow \text{any}$
		50	ABBIENDI	03G	OPAL	$H_1^0 \rightarrow A^0 A^0$
>105.4	95	51,52	HEISTER	02L	ALEP	$H_1^0 \rightarrow \gamma\gamma$
>109.1	95	53	HEISTER	02M	ALEP	$H_1^0 \rightarrow 2$ jets or $\tau^+ \tau^-$
none 12–56	95	54	ABBIENDI	01E	OPAL	A^0 , Type-II model
		55	ACCIARRI	00R	L3	$e^+ e^- \rightarrow H^0 \gamma$ and/or $H^0 \rightarrow \gamma\gamma$
		56	ACCIARRI	00R	L3	$e^+ e^- \rightarrow e^+ e^- H^0$
		57	GONZALEZ...	98B	RVUE	Anomalous coupling
		58	KRAWCZYK	97	RVUE	$(g-2)_\mu$
		59	ALEXANDER	96H	OPAL	$Z \rightarrow H^0 \gamma$

¹ SIRUNYAN 18F search for a narrow scalar resonance decaying to $H^0 H^0 \rightarrow W W b\bar{b}$ or $Z Z b\bar{b}$ in the final state $\ell\ell\nu\nu b\bar{b}$ in 35.9 fb⁻¹ of pp collisions at $E_{\text{cm}} = 13$ TeV. See their Fig. 7 for limits on cross section times branching ratios for $m_{H_2^0} = 250\text{--}900$ GeV.

² AABOUD 17 search for production of a scalar resonance decaying to $Z\gamma$ in 3.2 fb⁻¹ of pp collisions at $E_{\text{cm}} = 13$ TeV. See their Fig. 4 for the limits on cross section times branching ratio for $m_{H_2^0} = 0.25\text{--}3.0$ TeV.

³ AABOUD 17AW search for production of a scalar resonance decaying to $Z\gamma$ in 36.1 fb⁻¹ of pp collisions at $E_{\text{cm}} = 13$ TeV. See their Fig. 7 for limits on cross section times branching ratio for $m_{H_2^0} = 0.25\text{--}2.4$ TeV.

⁴ KHACHATRYAN 17D search for production of a scalar resonance decaying to $Z\gamma$ in 19.7 fb⁻¹ of pp collisions at $E_{\text{cm}} = 8$ TeV and 2.7 fb⁻¹ at $E_{\text{cm}} = 13$ TeV. See their Figs. 3 and 4 for the limits on cross section times branching ratio for $m_{H_2^0} = 0.2\text{--}2.0$ TeV.

⁵ KHACHATRYAN 17R search for production of a narrow scalar resonance decaying to $\gamma\gamma$ in 12.9 fb⁻¹ (taken in 2016) of pp collisions at $E_{\text{cm}} = 13$ TeV. See their Fig. 2 for limits on cross section times branching ratio for $m_{H_2^0} = 0.5\text{--}4.5$ TeV for several values of its width-to-mass ratio. Limits from combination with KHACHATRYAN 16M are shown in their Figs. 4 and 6.

- ⁶ SIRUNYAN 17CN search for a narrow scalar resonance decaying to $H^0 H^0 \rightarrow b\bar{b}\tau^+\tau^-$ in 18.3 fb^{-1} of pp collisions at $E_{\text{cm}} = 8 \text{ TeV}$. See their Fig. 5 (above) and Table II for limits on the cross section times branching ratios for $m_{H_2^0} = 0.3\text{--}1 \text{ TeV}$, and Fig. 6 (above) and Table III for the corresponding limits by combining with data from KHACHATRYAN 16BQ and KHACHATRYAN 15R.
- ⁷ SIRUNYAN 17Y search for production of a scalar resonance decaying to $Z\gamma$ in 19.7 fb^{-1} of pp collisions at $E_{\text{cm}} = 8 \text{ TeV}$ and 2.7 fb^{-1} at $E_{\text{cm}} = 13 \text{ TeV}$. See their Figs. 3, 4 and Table 3 for limits on cross section times branching ratio for $m_{H_2^0} = 0.7\text{--}3.0 \text{ TeV}$, and Fig. 5 for the corresponding limits for $m_{H_2^0} = 0.2\text{--}3.0 \text{ TeV}$ from combination with KHACHATRYAN 17D data.
- ⁸ AABOUD 16AB search for associated production of WH^0 with the decay $H^0 \rightarrow A^0 A^0 \rightarrow b\bar{b}b\bar{b}$ in 3.2 fb^{-1} of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$. See their Fig. 8 for limits on cross section times branching ratios for $m_{A^0} = 20\text{--}60 \text{ GeV}$.
- ⁹ AABOUD 16AE search for production of a narrow scalar resonance decaying to W^+W^- and ZZ in 3.2 fb^{-1} of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$. See their Fig. 4 for limits on cross section times branching ratio for $m_{H_2^0} = 0.5\text{--}3 \text{ TeV}$.
- ¹⁰ AABOUD 16H search for production of a scalar resonance decaying to $\gamma\gamma$ in 3.2 fb^{-1} of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$. See their Fig. 12 for limits on cross section times branching ratio for $m_{H_2^0} = 0.2\text{--}2 \text{ TeV}$ with different assumptions on the width.
- ¹¹ AABOUD 16I search for a narrow scalar resonance decaying to $H^0 H^0 \rightarrow b\bar{b}b\bar{b}$ in 3.2 fb^{-1} of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$. See their Fig. 10(c) for limits on cross section times branching ratios for $m_{H_2^0} = 0.5\text{--}3 \text{ TeV}$.
- ¹² AAD 16AX search for production of a heavy H^0 state decaying to ZZ in the final states $\ell^+\ell^-\ell^+\ell^-$, $\ell^+\ell^-\nu\bar{\nu}$, $\ell^+\ell^-q\bar{q}$, and $\nu\bar{\nu}q\bar{q}$ in 20.3 fb^{-1} of pp collisions at $E_{\text{cm}} = 8 \text{ TeV}$. See their Fig.12 for upper limits on $\sigma(H^0) \text{B}(H^0 \rightarrow ZZ)$ for m_{H^0} ranging from 140 GeV to 1000 GeV.
- ¹³ AAD 16C search for production of a heavy H^0 state decaying to W^+W^- in the final states $\ell\nu\ell\nu$ and $\ell\nu q\bar{q}$ in 20.3 fb^{-1} of pp collisions at $E_{\text{cm}} = 8 \text{ TeV}$. See their Figs. 12, 13, and 16 for upper limits on $\sigma(H^0) \text{B}(H^0 \rightarrow W^+W^-)$ for m_{H^0} ranging from 300 GeV to 1000 or 1500 GeV with various assumptions on the total width of H^0 .
- ¹⁴ AAD 16L search for the decay $H^0 \rightarrow A^0 A^0 \rightarrow \gamma\gamma\gamma\gamma$ in 20.3 fb^{-1} of pp collisions at $E_{\text{cm}} = 8 \text{ TeV}$. See their Fig. 4 (upper right) for limits on cross section times branching ratios (normalized to the SM H^0 cross section) for $m_{A^0} = 10\text{--}60 \text{ GeV}$.
- ¹⁵ AAD 16L search for the decay $H_2^0 \rightarrow A^0 A^0 \rightarrow \gamma\gamma\gamma\gamma$ in 20.3 fb^{-1} of pp collisions at $E_{\text{cm}} = 8 \text{ TeV}$. See their Fig. 4 (lower right) for limits on cross section times branching ratios for $m_{H_2^0} = 600 \text{ GeV}$ and $m_{A^0} = 10\text{--}245 \text{ GeV}$, and Table 5 for limits for $m_{H_2^0} = 300$ and 900 GeV .
- ¹⁶ AALTONEN 16C search for electroweak associated production of $H_1^0 H^\pm$ followed by the decays $H^\pm \rightarrow H_1^0 W^*$, $H_1^0 \rightarrow \gamma\gamma$ for $m_{H_1^0} = 10\text{--}105 \text{ GeV}$ and $m_{H^\pm} = 30\text{--}300 \text{ GeV}$. See their Fig. 3 for excluded parameter region in a two-doublet model in which H_1^0 has no direct decay to fermions.
- ¹⁷ KHACHATRYAN 16BG search for a narrow scalar resonance decaying to $H^0 H^0 \rightarrow b\bar{b}b\bar{b}$ in 19.7 fb^{-1} of pp collisions at $E_{\text{cm}} = 8 \text{ TeV}$. See their Fig. 6 for limits on the cross section times branching ratios for $m_{H_2^0} = 1.15\text{--}3 \text{ TeV}$.

- 18 KHACHATRYAN 16BQ search for a resonance decaying to $H^0 H^0 \rightarrow \gamma\gamma b\bar{b}$ in 19.7 fb^{-1} of pp collisions at $E_{\text{cm}} = 8 \text{ TeV}$. See their Fig. 9 for limits on the cross section times branching ratios for $m_{H_2^0} = 0.26\text{--}1.1 \text{ TeV}$.
- 19 KHACHATRYAN 16F search for the decay $H^0 \rightarrow H_1^0 H_1^0 \rightarrow \tau^+ \tau^- \tau^+ \tau^-$ in 19.7 fb^{-1} of pp collisions at $E_{\text{cm}} = 8 \text{ TeV}$. See their Fig. 8 for cross section limits for $m_{H_1^0} = 4\text{--}8 \text{ GeV}$.
- 20 KHACHATRYAN 16M search for production of a narrow resonance decaying to $\gamma\gamma$ in 19.7 fb^{-1} of pp collisions at $E_{\text{cm}} = 8 \text{ TeV}$ and 3.3 fb^{-1} at $E_{\text{cm}} = 13 \text{ TeV}$. See their Fig. 3 (top) for limits on cross section times branching ratio for $m_{H_2^0} = 0.5\text{--}4 \text{ TeV}$.
- 21 KHACHATRYAN 16P search for gluon fusion production of an H_2^0 decaying to $H^0 H^0 \rightarrow b\bar{b}\tau^+\tau^-$ in 19.7 fb^{-1} of pp collisions at $E_{\text{cm}} = 8 \text{ TeV}$. See their Fig. 8 (lower right) for cross section limits for $m_{H_2^0} = 260\text{--}350 \text{ GeV}$.
- 22 KHACHATRYAN 16P search for gluon fusion production of an A^0 decaying to $ZH^0 \rightarrow \ell^+\ell^-\tau^+\tau^-$ in 19.7 fb^{-1} of pp collisions at $E_{\text{cm}} = 8 \text{ TeV}$. See their Fig. 10 for cross section limits for $m_{H_2^0} = 220\text{--}350 \text{ GeV}$.
- 23 AAD 15BK search for production of a heavy H_2^0 decaying to $H^0 H^0$ in the final state $b\bar{b}b\bar{b}$ in 19.5 fb^{-1} of pp collisions at $E_{\text{cm}} = 8 \text{ TeV}$. See their Fig. 14(c) for $\sigma(H_2^0) \text{B}(H_2^0 \rightarrow H^0 H^0)$ for $m_{H_2^0} = 500\text{--}1500 \text{ GeV}$ with $\Gamma_{H_2^0} = 1 \text{ GeV}$.
- 24 AAD 15BZ search for the decay $H^0 \rightarrow A^0 A^0 \rightarrow \mu^+\mu^-\tau^+\tau^-$ ($m_{H^0} = 125 \text{ GeV}$) in 20.3 fb^{-1} of pp collisions at $E_{\text{cm}} = 8 \text{ TeV}$. See their Fig. 6 for limits on cross section times branching ratio for $m_{A^0} = 3.7\text{--}50 \text{ GeV}$.
- 25 AAD 15BZ search for a state H_2^0 via the decay $H_2^0 \rightarrow A^0 A^0 \rightarrow \mu^+\mu^-\tau^+\tau^-$ in 20.3 fb^{-1} of pp collisions at $E_{\text{cm}} = 8 \text{ TeV}$. See their Fig. 6 for limits on cross section times branching ratio for $m_{H_2^0} = 100\text{--}500 \text{ GeV}$ and $m_{A^0} = 5 \text{ GeV}$.
- 26 AAD 15CE search for production of a heavy H_2^0 decaying to $H^0 H^0$ in the final states $b\bar{b}\tau^+\tau^-$ and $\gamma\gamma WW^*$ in 20.3 fb^{-1} of pp collisions at $E_{\text{cm}} = 8 \text{ TeV}$ and combine with data from AAD 15H and AAD 15BK. A limit $\sigma(H_2^0) \text{B}(H_2^0 \rightarrow H^0 H^0) < 2.1\text{--}0.011 \text{ pb}$ (95% CL) is given for $m_{H_2^0} = 260\text{--}1000 \text{ GeV}$. See their Fig. 6.
- 27 AAD 15H search for production of a heavy H_2^0 decaying to $H^0 H^0$ in the final state $\gamma\gamma b\bar{b}$ in 20.3 fb^{-1} of pp collisions at $E_{\text{cm}} = 8 \text{ TeV}$. A limit of $\sigma(H_2^0) \text{B}(H_2^0 \rightarrow H^0 H^0) < 3.5\text{--}0.7 \text{ pb}$ is given for $m_{H_2^0} = 260\text{--}500 \text{ GeV}$ at 95% CL. See their Fig. 3.
- 28 AAD 15S search for production of A^0 decaying to $ZH^0 \rightarrow \ell^+\ell^-b\bar{b}$, $\nu\bar{\nu}b\bar{b}$ and $\ell^+\ell^-\tau^+\tau^-$ in 20.3 fb^{-1} of pp collisions at $E_{\text{cm}} = 8 \text{ TeV}$. See their Fig. 3 for cross section limits for $m_{A^0} = 200\text{--}1000 \text{ GeV}$.
- 29 KHACHATRYAN 15AW search for production of a heavy state H_2^0 of an electroweak singlet extension of the Standard Model via the decays of H_2^0 to W^+W^- and ZZ in up to 5.1 fb^{-1} of pp collisions at $E_{\text{cm}} = 7 \text{ TeV}$ and up to 19.7 fb^{-1} at $E_{\text{cm}} = 8 \text{ TeV}$ in the range $m_{H_2^0} = 145\text{--}1000 \text{ GeV}$. See their Figs. 8 and 9 for limits in the parameter space of the model.
- 30 KHACHATRYAN 15BB search for production of a resonance H^0 decaying to $\gamma\gamma$ in 19.7 fb^{-1} of pp collisions at $E_{\text{cm}} = 8 \text{ TeV}$. See their Fig. 7 for limits on cross section times branching ratio for $m_{H^0} = 150\text{--}850 \text{ GeV}$.

- 31 KHACHATRYAN 15N search for production of A^0 decaying to $ZH^0 \rightarrow \ell^+ \ell^- b\bar{b}$ in 19.7 fb^{-1} of pp collisions at $E_{\text{cm}} = 8 \text{ TeV}$. See their Fig. 3 for limits on cross section times branching ratios for $m_{A^0} = 225\text{--}600 \text{ GeV}$.
- 32 KHACHATRYAN 15O search for production of a high-mass narrow resonance A^0 decaying to $ZH^0 \rightarrow q\bar{q}\tau^+\tau^-$ in 19.7 fb^{-1} of pp collisions at $E_{\text{cm}} = 8 \text{ TeV}$. See their Fig. 6 for limits on cross section times branching ratios for $m_{A^0} = 800\text{--}2500 \text{ GeV}$.
- 33 KHACHATRYAN 15R search for a narrow scalar resonance decaying to $H^0 H^0 \rightarrow b\bar{b}b\bar{b}$ in 17.9 fb^{-1} of pp collisions at $E_{\text{cm}} = 8 \text{ TeV}$. See their Fig. 5 (top) for limits on cross section times branching ratios for $m_{H^0} = 0.27\text{--}1.1 \text{ TeV}$.
- 34 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 $E_{\text{cm}} = 8 \text{ TeV}$. See their Fig. 4 for limits on cross section times branching ratio for $m_{H^0} = 65\text{--}600 \text{ GeV}$.
- 35 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 $b\bar{b}$ in 20.3 fb^{-1} of pp collisions at $E_{\text{cm}} = 8 \text{ TeV}$. See their Table III for limits on cross section times branching ratio for $m_{H^0_2} = 325\text{--}1025 \text{ GeV}$ and $m_{H^\pm} = 225\text{--}925 \text{ GeV}$.
- 36 CHATRCHYAN 14G search for a second H^0 state decaying to $WW^{(*)}$ in addition to the observed signal at about 125 GeV using 4.9 fb^{-1} of pp collisions at $E_{\text{cm}} = 7 \text{ TeV}$ and 19.4 fb^{-1} at $E_{\text{cm}} = 8 \text{ TeV}$. See their Fig. 21 (right) for cross section limits in the mass range $110\text{--}600 \text{ GeV}$.
- 37 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 $E_{\text{cm}} = 7 \text{ TeV}$ and 19.7 fb^{-1} at $E_{\text{cm}} = 8 \text{ TeV}$. See their Figs. 27 and 28 for cross section limits in the mass range $110\text{--}150 \text{ GeV}$.
- 38 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 $H'^0 \rightarrow H^\pm W^\mp$, $H^\pm \rightarrow W^\pm H^0$, $H^0 \rightarrow b\bar{b}$ in the final state $\ell\nu$ plus 4 jets in 8.7 fb^{-1} of $p\bar{p}$ collisions at $E_{\text{cm}} = 1.96 \text{ TeV}$. See their Fig. 4 for limits on cross section times branching ratio in the $m_{H^\pm}\text{--}m_{H'^0}$ plane for $m_{H^0} = 126 \text{ GeV}$.
- 39 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 $E_{\text{cm}} = 7 \text{ TeV}$. See their Fig. 2 for limits on cross section times branching ratio.
- 40 AALTONEN 11P search in 2.7 fb^{-1} of $p\bar{p}$ collisions at $E_{\text{cm}} = 1.96 \text{ TeV}$ 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 $90 < m_{H^+} < 160 \text{ GeV}$.
- 41 ABBIENDI 10 search for $e^+ e^- \rightarrow ZH^0$ with the decay chain $H^0 \rightarrow \tilde{\chi}_1^0 \tilde{\chi}_2^0$, $\tilde{\chi}_2^0 \rightarrow \tilde{\chi}_1^0 + (\gamma \text{ or } Z^*)$, when $\tilde{\chi}_1^0$ and $\tilde{\chi}_2^0$ 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 $B(H^0 \rightarrow \tilde{\chi}_1^0 \tilde{\chi}_2^0) = 1$.
- 42 SCHAEEL 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 $Z \rightarrow \ell^+ \ell^-$, $\nu\bar{\nu}$ at $E_{\text{cm}} = 183\text{--}209 \text{ GeV}$. For a $H^0 Z Z$ coupling equal to the SM value, $B(H^0 \rightarrow A^0 A^0) = B(A^0 \rightarrow \tau^+ \tau^-) = 1$, and $m_{A^0} = 4\text{--}10 \text{ GeV}$, m_{H^0} up to 107 GeV is excluded at 95% CL.
- 43 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 $p\bar{p}$ collisions at $E_{\text{cm}} = 1.96 \text{ TeV}$. See their Fig. 3 for limits on $\sigma(H^0) \cdot B(H^0 \rightarrow A^0 A^0)$ for $m_{A^0} = 3.6\text{--}19 \text{ GeV}$.

- 44 ABBIENDI 05A search for $e^+e^- \rightarrow H_1^0 A^0$ in general Type-II two-doublet models, with decays $H_1^0, A^0 \rightarrow q\bar{q}, gg, \tau^+\tau^-$, and $H_1^0 \rightarrow A^0 A^0$.
- 45 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 $B(H^0 \rightarrow jj) = 1$.
- 46 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.
- 47 ACHARD 04B search for $e^+e^- \rightarrow H^0 Z$ with H^0 decaying to $b\bar{b}, c\bar{c}$, or gg . The limit is for SM production cross section with $B(H^0 \rightarrow jj) = 1$.
- 48 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 $H^0 \rightarrow f\bar{f}, \gamma\gamma, Z\gamma$, and W^*W at $E_{\text{cm}} = 189\text{--}209$ GeV. See paper for limits.
- 49 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 $Z \rightarrow \nu\bar{\nu}$ 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.
- 50 ABBIENDI 03G search for $e^+e^- \rightarrow H_1^0 Z$ followed by $H_1^0 \rightarrow A^0 A^0, A^0 \rightarrow c\bar{c}, gg$, or $\tau^+\tau^-$ in the region $m_{H_1^0} = 45\text{--}86$ GeV and $m_{A^0} = 2\text{--}11$ GeV. See their Fig. 7 for the limits.
- 51 Search for associated production of a $\gamma\gamma$ resonance with a Z boson, followed by $Z \rightarrow q\bar{q}, \ell^+\ell^-$, or $\nu\bar{\nu}$, at $E_{\text{cm}} \leq 209$ GeV. The limit is for a H^0 with SM production cross section and $B(H^0 \rightarrow f\bar{f})=0$ for all fermions f .
- 52 For $B(H^0 \rightarrow \gamma\gamma)=1$, $m_{H^0} > 113.1$ GeV is obtained.
- 53 HEISTER 02M search for $e^+e^- \rightarrow H^0 Z$, assuming that H^0 decays to $q\bar{q}, gg$, or $\tau^+\tau^-$ only. The limit assumes SM production cross section.
- 54 ABBIENDI 01E search for neutral Higgs bosons in general Type-II two-doublet models, at $E_{\text{cm}} \leq 189$ GeV. In addition to usual final states, the decays $H_1^0, A^0 \rightarrow q\bar{q}, gg$ are searched for. See their Figs. 15,16 for excluded regions.
- 55 ACCIARRI 00R search for $e^+e^- \rightarrow H^0\gamma$ with $H^0 \rightarrow b\bar{b}, Z\gamma$, 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.
- 56 ACCIARRI 00R search for the two-photon type processes $e^+e^- \rightarrow e^+e^-H^0$ with $H^0 \rightarrow b\bar{b}$ or $\gamma\gamma$. See their Fig. 4 for limits on $\Gamma(H^0 \rightarrow \gamma\gamma) \cdot B(H^0 \rightarrow \gamma\gamma \text{ or } b\bar{b})$ for $m_{H^0}=70\text{--}170$ GeV.
- 57 GONZALEZ-GARCIA 98B use $D\bar{D}$ limit for $\gamma\gamma$ events with missing E_T in $p\bar{p}$ collisions (ABBOTT 98) to constrain possible ZH or WH production followed by unconventional $H \rightarrow \gamma\gamma$ decay which is induced by higher-dimensional operators. See their Figs. 1 and 2 for limits on the anomalous couplings.
- 58 KRAWCZYK 97 analyse the muon anomalous magnetic moment in a two-doublet Higgs model (with type II Yukawa couplings) assuming no $H_1^0 Z Z$ coupling and obtain $m_{H_1^0} \gtrsim 5$ GeV or $m_{A^0} \gtrsim 5$ GeV for $\tan\beta > 50$. Other Higgs bosons are assumed to be much heavier.
- 59 ALEXANDER 96H give $B(Z \rightarrow H^0\gamma) \times B(H^0 \rightarrow q\bar{q}) < 1\text{--}4 \times 10^{-5}$ (95%CL) and $B(Z \rightarrow H^0\gamma) \times B(H^0 \rightarrow b\bar{b}) < 0.7\text{--}2 \times 10^{-5}$ (95%CL) in the range $20 < m_{H^0} < 80$ GeV.
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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 128–1000 (CL = 95%)				
none 145–1000	95	¹ KHACHATRY...15AW	CMS	$pp \rightarrow H^0 X$ combined
none 90–102, 149–172	95	² AALTONEN 13L	CDF	$pp \rightarrow H^0 X$, combined
none 90–109, 149–182	95	³ AALTONEN 13M	TEVA	Tevatron combined
none 90–101, 157–178	95	⁴ ABAZOV 13L	D0	$p\bar{p} \rightarrow H^0 X$, combined
none 110–121.5, 128–145	95	⁵ CHATRCHYAN12N	CMS	$pp \rightarrow H^0 X$ combined
>114.1	95	⁶ ABDALLAH 04	DLPH	$e^+ e^- \rightarrow H^0 Z$
>112.7	95	⁶ ABBIENDI 03B	OPAL	$e^+ e^- \rightarrow H^0 Z$
>114.4	95	^{6,7} HEISTER 03D	LEP	$e^+ e^- \rightarrow H^0 Z$
>111.5	95	^{6,8} HEISTER 02	ALEP	$e^+ e^- \rightarrow H^0 Z$
>112.0	95	⁶ ACHARD 01C	L3	$e^+ e^- \rightarrow H^0 Z$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●				
none 132–200	95	⁹ AAD 15AA	ATLS	$pp \rightarrow H^0 X, H^0 \rightarrow WW^{(*)}$
		¹⁰ AAD 15G	ATLS	$pp \rightarrow H^0 W/ZX, H^0 \rightarrow b\bar{b}$
		¹¹ AAD 14AS	ATLS	$pp \rightarrow H^0 X, H^0 \rightarrow \mu\mu$
		¹² AAD 14J	ATLS	$pp \rightarrow H^0 X, H^0 \rightarrow Z\gamma$
none 114.5–119, 129.5–832	95	¹³ CHATRCHYAN14AA	CMS	$pp \rightarrow H^0 X, H^0 \rightarrow 4\ell$
		¹⁴ CHATRCHYAN14AI	CMS	$pp \rightarrow H^0 W/ZX, H^0 \rightarrow b\bar{b}$
none 127–600	95	¹⁵ CHATRCHYAN14G	CMS	$pp \rightarrow H^0 X, H^0 \rightarrow WW^{(*)}$
		¹⁶ AALTONEN 13B	CDF	$p\bar{p} \rightarrow H^0 W/ZX, H^0 \rightarrow b\bar{b}$
		¹⁷ AALTONEN 13C	CDF	$p\bar{p} \rightarrow H^0 X, H^0 \rightarrow b\bar{b}$

none 149–172	95	18 AALTONEN 13K CDF	$p\bar{p} \rightarrow H^0 X, H^0 \rightarrow WW^{(*)}$
		19 ABAZOV 13E D0	$p\bar{p} \rightarrow H^0 X, 4\ell$
		20 ABAZOV 13F D0	$p\bar{p} \rightarrow H^0 X, \ell\tau jj$
none 159–176	95	21 ABAZOV 13G D0	$p\bar{p} \rightarrow H^0 X, H^0 \rightarrow WW^{(*)}$
		22 ABAZOV 13H D0	$p\bar{p} \rightarrow H^0 X, H^0 \rightarrow \gamma\gamma$
		23 ABAZOV 13I D0	$p\bar{p} \rightarrow H^0 X, \ell\nu jj$
		24 ABAZOV 13J D0	$p\bar{p} \rightarrow H^0 X, \text{leptonic}$
		25 ABAZOV 13K D0	$p\bar{p} \rightarrow H^0 ZX$
		26 CHATRCHYAN 13AL CMS	$pp \rightarrow H^0 X, H^0 \rightarrow \tau\tau, WW^{(*)}, ZZ^{(*)}$
none 145–710	95	27 CHATRCHYAN 13BK CMS	$pp \rightarrow H^0 X, H^0 \rightarrow Z\gamma$
		28 CHATRCHYAN 13Q CMS	$pp \rightarrow H^0 X \text{ combined}$
		29 CHATRCHYAN 13X CMS	$pp \rightarrow H^0 t\bar{t} X$
none 113–122, 128–133, 138–149	95	30 CHATRCHYAN 13Y CMS	$pp \rightarrow H^0 X, H^0 \rightarrow \gamma\gamma$
		31 CHATRCHYAN 13Y CMS	$pp \rightarrow H^0 X, H^0 \rightarrow ZZ^*$
none 130–164, 170–180	95	32 CHATRCHYAN 13Y CMS	$pp \rightarrow H^0 X, H^0 \rightarrow WW^*$
none 129–160	95	33 AAD 12AI ATLS	$pp \rightarrow H^0 X \text{ combined}$
none 111–122, 131–559	95	34 AAD 12AJ ATLS	$pp \rightarrow H^0 X, H^0 \rightarrow WW^{(*)}$
none 133–261	95	35 AAD 12BU ATLS	$pp \rightarrow H^0 X, H^0 \rightarrow \tau^+\tau^-$
none 319–558	95	36 AAD 12BZ ATLS	$pp \rightarrow H^0 X, H^0 \rightarrow ZZ$
none 300–322, 353–410	95	37 AAD 12CA ATLS	$pp \rightarrow H^0 X, H^0 \rightarrow ZZ$
		38 AAD 12CN ATLS	$pp \rightarrow H^0 W/ZX, H^0 \rightarrow b\bar{b}$
none 134–156, 182–233, 256–265, 268–415	95	39 AAD 12CO ATLS	$pp \rightarrow H^0 X, H^0 \rightarrow WW$
		40 AAD 12D ATLS	$pp \rightarrow H^0 X, H^0 \rightarrow ZZ^{(*)}$
		41 AAD 12G ATLS	$pp \rightarrow H^0 X, H^0 \rightarrow \gamma\gamma$
none 113–115, 134.5–136	95	42 AALTONEN 12AK CDF	$p\bar{p} \rightarrow H^0 t\bar{t} X$
		43 AALTONEN 12AM CDF	$p\bar{p} \rightarrow H^0 X, \text{inclusive } 4\ell$
		44 AALTONEN 12AN CDF	$p\bar{p} \rightarrow H^0 X, H^0 \rightarrow \gamma\gamma$
		45 AALTONEN 12J CDF	$p\bar{p} \rightarrow H^0 X, H^0 \rightarrow \tau\tau$
		46 AALTONEN 12Q CDF	$p\bar{p} \rightarrow H^0 ZX, H^0 \rightarrow b\bar{b}$
		47 AALTONEN 12T TEVA	$p\bar{p} \rightarrow H^0 W/ZX, H^0 \rightarrow b\bar{b}$
		48 ABAZOV 12K D0	$p\bar{p} \rightarrow H^0 W/ZX, H^0 \rightarrow b\bar{b}$
		49,50 CHATRCHYAN 12AY CMS	$pp \rightarrow H^0 WX, H^0 ZX$
none 100–106	95	51 CHATRCHYAN 12C CMS	$pp \rightarrow H^0 X, H^0 \rightarrow ZZ$
		52 CHATRCHYAN 12D CMS	$pp \rightarrow H^0 X, H^0 \rightarrow ZZ^{(*)}$
		53 CHATRCHYAN 12E CMS	$pp \rightarrow H^0 X, H^0 \rightarrow WW^{(*)}$
none 129–270	95	54 CHATRCHYAN 12F CMS	$pp \rightarrow H^0 WX, H^0 ZX$
none 128–132	95	55 CHATRCHYAN 12G CMS	$pp \rightarrow H^0 X, H^0 \rightarrow \gamma\gamma$
none 134–158, 180–305, 340–465	95	56 CHATRCHYAN 12H CMS	$pp \rightarrow H^0 X, H^0 \rightarrow ZZ^{(*)}$
		57 CHATRCHYAN 12I CMS	$pp \rightarrow H^0 X, H^0 \rightarrow ZZ$
none 270–440	95	58 CHATRCHYAN 12K CMS	$pp \rightarrow H^0 X, H^0 \rightarrow \tau^+\tau^-$

		59	ABAZOV	11G	D0	$p\bar{p} \rightarrow H^0 X, H^0 \rightarrow WW^{(*)}$	
		60	CHATRCHYAN	11J	CMS	$pp \rightarrow H^0 X, H^0 \rightarrow WW$	
none	162–166	95	61	AALTONEN	10F	TEVA	$p\bar{p} \rightarrow H^0 X, H^0 \rightarrow WW^{(*)}$
			62	AALTONEN	10M	TEVA	$p\bar{p} \rightarrow ggX \rightarrow H^0 X, H^0 \rightarrow WW^{(*)}$
			63	AALTONEN	09A	CDF	$p\bar{p} \rightarrow H^0 X, H^0 \rightarrow WW^{(*)}$
			64	ABAZOV	09U	D0	$H^0 \rightarrow \tau^+\tau^-$
			65	ABAZOV	06	D0	$p\bar{p} \rightarrow H^0 X, H^0 \rightarrow WW^*$
			66	ABAZOV	06O	D0	$p\bar{p} \rightarrow H^0 WX, H^0 \rightarrow WW^*$

¹ KHACHATRYAN 15AW search for H^0 production in the decays $H^0 \rightarrow W^+W^- \rightarrow \ell\nu\ell\nu, \ell\nu qq$, and $H^0 \rightarrow ZZ \rightarrow 4\ell, \ell\ell\tau\tau, \ell\ell\nu\nu$, and $\ell\ell qq$ in up to 5.1 fb^{-1} of pp collisions at $E_{\text{cm}} = 7 \text{ TeV}$ and up to 19.7 fb^{-1} at $E_{\text{cm}} = 8 \text{ TeV}$ in the range $m_{H^0} = 145\text{--}1000 \text{ GeV}$. See their Fig. 7 for limits on cross section times branching ratio.

² AALTONEN 13L combine all CDF searches with $9.45\text{--}10.0 \text{ fb}^{-1}$ of $p\bar{p}$ collisions at $E_{\text{cm}} = 1.96 \text{ TeV}$. A limit on cross section times branching ratio which corresponds to $(0.45\text{--}4.8)$ times the expected Standard Model cross section is given for $m_{H^0} = 90\text{--}200 \text{ GeV}$ at 95% CL. An excess of events over background is observed with a local significance of 2.0σ at $m_{H^0} = 125 \text{ GeV}$. 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.

³ AALTONEN 13M combine all Tevatron data from the CDF and D0 Collaborations. A limit on cross section times branching ratio which corresponds to $(0.37\text{--}3.1)$ times the expected Standard Model cross section is given for $m_{H^0} = 90\text{--}200 \text{ GeV}$ at 95% CL. An excess of events over background is observed with a local significance of 3.0σ at $m_{H^0} = 125 \text{ GeV}$. 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.

⁴ ABAZOV 13L combine all D0 results with up to 9.7 fb^{-1} of $p\bar{p}$ collisions at $E_{\text{cm}} = 1.96 \text{ TeV}$. A limit on cross section times branching ratio which corresponds to $(0.66\text{--}3.1)$ times the expected Standard Model cross section is given in the range $m_{H^0} = 90\text{--}200 \text{ GeV}$ at 95% CL. An excess of events over background is observed with a local significance of 1.7σ at $m_{H^0} = 125 \text{ GeV}$. 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.

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 $b\bar{b}$ in $4.9\text{--}5.1 \text{ fb}^{-1}$ of pp collisions at $E_{\text{cm}} = 7 \text{ TeV}$ and $5.1\text{--}5.3 \text{ fb}^{-1}$ at $E_{\text{cm}} = 8 \text{ TeV}$. The expected exclusion region for no signal is $110\text{--}145 \text{ GeV}$ at 99.9% CL. See also CHATRCHYAN 13Y.

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

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 $q\bar{q}q\bar{q}, q\bar{q}\ell\bar{\ell}, q\bar{q}\tau^+\tau^-$.

⁹ AAD 15AA search for $H^0 \rightarrow WW^{(*)}$ in 4.5 fb^{-1} of pp collisions at $E_{\text{cm}} = 7 \text{ TeV}$ and 20.3 fb^{-1} at $E_{\text{cm}} = 8 \text{ TeV}$. A limit on cross section times branching ratio which corresponds to $(0.2\text{--}6)$ times the expected Standard Model cross section is given for $m_{H^0} = 110\text{--}200 \text{ GeV}$ at 95% CL.

¹⁰ AAD 15G search for WH^0 and ZH^0 production followed by $H^0 \rightarrow b\bar{b}$ in 4.7 fb^{-1} of pp collisions at $E_{\text{cm}} = 7 \text{ TeV}$ and 20.3 fb^{-1} at $E_{\text{cm}} = 8 \text{ TeV}$. A limit on the cross section times branching ratio which corresponds to $(0.8\text{--}2.6)$ times the expected Standard Model cross section is given for $m_{H^0} = 110\text{--}140 \text{ GeV}$ at 95% CL.

- 11 AAD 14AS search for $H^0 \rightarrow \mu^+ \mu^-$ in 4.5 fb^{-1} of pp collisions at $E_{\text{cm}} = 7 \text{ TeV}$ and 20.3 fb^{-1} at $E_{\text{cm}} = 8 \text{ TeV}$. 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 $m_{H^0} = 120\text{--}150 \text{ GeV}$ at 95% CL.
- 12 AAD 14J search for $H^0 \rightarrow Z\gamma \rightarrow \ell\ell\gamma$ in 4.5 fb^{-1} of pp collisions at $E_{\text{cm}} = 7 \text{ TeV}$ and 20.3 fb^{-1} at $E_{\text{cm}} = 8 \text{ TeV}$. A limit on cross section times branching ratio which corresponds to (4–18) times the expected Standard Model cross section is given for $m_{H^0} = 120\text{--}150 \text{ GeV}$ at 95% CL.
- 13 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 $E_{\text{cm}} = 7 \text{ TeV}$ and 19.7 fb^{-1} at $E_{\text{cm}} = 8 \text{ TeV}$. The expected exclusion region for no signal is 115–740 GeV at the 95% CL. See their Fig. 18 for cross section limits for $m_{H^0} = 110\text{--}1000 \text{ GeV}$.
- 14 CHATRCHYAN 14AI search for WH^0 and ZH^0 production followed by $H^0 \rightarrow b\bar{b}$ in up to 5.1 fb^{-1} of pp collisions at $E_{\text{cm}} = 7 \text{ TeV}$ and up to 18.9 fb^{-1} at $E_{\text{cm}} = 8 \text{ TeV}$. A limit on the cross section times branching ratio which corresponds to (1–3) times the expected Standard Model cross section is given for $m_{H^0} = 110\text{--}135 \text{ GeV}$ at 95% CL.
- 15 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 $E_{\text{cm}} = 7 \text{ TeV}$ and 19.4 fb^{-1} at $E_{\text{cm}} = 8 \text{ TeV}$. 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 $m_{H^0} = 110\text{--}600 \text{ GeV}$.
- 16 AALTONEN 13B search for associated $H^0 Z$ production in the final state $H^0 \rightarrow b\bar{b}$, $Z \rightarrow \nu\bar{\nu}$, and $H^0 W$ production in $H^0 \rightarrow b\bar{b}$, $W \rightarrow \ell\nu$ (ℓ not identified) with an improved b identification algorithm in 9.45 fb^{-1} of $p\bar{p}$ collisions at $E_{\text{cm}} = 1.96 \text{ TeV}$. 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 $m_{H^0} = 90\text{--}150 \text{ GeV}$ at 95% CL. The limit for $m_{H^0} = 125 \text{ GeV}$ is 3.06, where 3.33 is expected for no signal.
- 17 AALTONEN 13C search for associated $H^0 W$ and $H^0 Z$ as well as vector-boson fusion $H^0 q\bar{q}'$ production in the final state $H^0 \rightarrow b\bar{b}$, $W/Z \rightarrow q\bar{q}$ with 9.45 fb^{-1} of $p\bar{p}$ collisions at $E_{\text{cm}} = 1.96 \text{ TeV}$. 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 $m_{H^0} = 100\text{--}150 \text{ GeV}$ at 95% CL. The limit for $m_{H^0} = 125 \text{ GeV}$ is 9.0, where 11.0 is expected for no signal.
- 18 AALTONEN 13K search for H^0 production (with a possible additional W or Z) in the final state $H^0 \rightarrow WW^{(*)} \rightarrow \ell\nu\ell\nu$ in 9.7 fb^{-1} of $p\bar{p}$ collisions at $E_{\text{cm}} = 1.96 \text{ TeV}$. 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 $m_{H^0} = 110\text{--}200 \text{ GeV}$ at 95% CL. The limit at $m_{H^0} = 125 \text{ GeV}$ 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.
- 19 ABAZOV 13E search for H^0 production in four-lepton final states from $H^0 \rightarrow ZZ^{(*)}$ and $H^0 Z$ in $9.6\text{--}9.8 \text{ fb}^{-1}$ of $p\bar{p}$ collisions at $E_{\text{cm}} = 1.96 \text{ TeV}$. 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 $m_{H^0} = 115\text{--}200 \text{ GeV}$ at 95% CL. The limit for $m_{H^0} = 125 \text{ GeV}$ is 42.3, where 42.8 is expected for no signal.
- 20 ABAZOV 13F search for H^0 production in final states $e\tau jj$ and $\mu\tau jj$ in 9.7 fb^{-1} of $p\bar{p}$ collisions at $E_{\text{cm}} = 1.96 \text{ TeV}$. The search is sensitive to $H \rightarrow \tau\tau$ and $H \rightarrow WW^{(*)}$. 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 $m_{H^0} = 105\text{--}150 \text{ GeV}$ at 95% CL. The limit for $m_{H^0} = 125 \text{ GeV}$ is 11.3, where 9.0 is expected for no signal.

- 21 ABAZOV 13G search for H^0 production in final states $H^0 \rightarrow WW^{(*)} \rightarrow \ell^+ \nu \ell^- \nu$ in 9.7 fb^{-1} of $p\bar{p}$ collisions at $E_{\text{cm}} = 1.96 \text{ TeV}$ and give a limit on cross section times branching ratio for $m_{H^0} = 100\text{--}150 \text{ GeV}$ at 95% CL. The limit for $m_{H^0} = 125 \text{ GeV}$ 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.
- 22 ABAZOV 13H search for H^0 production with the decay $H^0 \rightarrow \gamma\gamma$ in 9.6 fb^{-1} of $p\bar{p}$ collisions at $E_{\text{cm}} = 1.96 \text{ TeV}$. 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 $m_{H^0} = 100\text{--}150 \text{ GeV}$ at 95% CL. The limit for $m_{H^0} = 125 \text{ GeV}$ is 12.8, where 8.7 is expected for no signal.
- 23 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 $p\bar{p}$ collisions at $E_{\text{cm}} = 1.96 \text{ TeV}$. The search is mainly sensitive to $H^0 W \rightarrow b\bar{b}\ell\nu$, $H^0 \rightarrow WW^{(*)} \rightarrow \ell\nu q\bar{q}$, and $H^0 V \rightarrow VWW^{(*)} \rightarrow \ell\nu q\bar{q}q\bar{q}$ ($V = W, Z$). 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 $m_{H^0} = 90\text{--}200 \text{ GeV}$ at 95% CL. The limit for $m_{H^0} = 125 \text{ GeV}$ 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.
- 24 ABAZOV 13J search for H^0 production in the final states $e e \mu$, $e \mu \mu$, $\mu \tau \tau$, and $e^\pm \mu^\pm$ in $8.6\text{--}9.7 \text{ fb}^{-1}$ of $p\bar{p}$ collisions at $E_{\text{cm}} = 1.96 \text{ TeV}$. The search is sensitive to WH^0 , ZH^0 and gluon fusion production with $H^0 \rightarrow WW^{(*)}$, $ZZ^{(*)}$, decaying to leptonic final states, and to WH^0 , ZH^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 $m_{H^0} = 100\text{--}200 \text{ GeV}$ at 95% CL. The limit for $m_{H^0} = 125 \text{ GeV}$ is 8.4, where 6.3 is expected for no signal.
- 25 ABAZOV 13K search for associated $H^0 Z$ production in the final states $\ell\ell b\bar{b}$ with b identification in 9.7 fb^{-1} of $p\bar{p}$ collisions at $E_{\text{cm}} = 1.96 \text{ TeV}$. A limit on cross section times branching ratio which corresponds to (1.8–53) times the expected Standard Model cross section is given for $m_{H^0} = 90\text{--}150 \text{ GeV}$ at 95% CL. The limit for $m_{H^0} = 125 \text{ GeV}$ is 7.1, where 5.1 is expected for no signal.
- 26 CHATRCHYAN 13AL search for $H^0 \rightarrow \tau^+ \tau^-$, $WW^{(*)}$, and $ZZ^{(*)}$ in 5.1 fb^{-1} and 5.3 fb^{-1} of pp collisions at $E_{\text{cm}} = 7$ 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.
- 27 CHATRCHYAN 13BK search for $H^0 \rightarrow Z\gamma \rightarrow \ell\ell\gamma$ in 5.0 fb^{-1} of pp collisions at $E_{\text{cm}} = 7 \text{ TeV}$ and 19.6 fb^{-1} at $E_{\text{cm}} = 8 \text{ TeV}$. 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 $m_{H^0} = 120\text{--}160 \text{ GeV}$ at 95% CL. The limit for $m_{H^0} = 125 \text{ GeV}$ is 9.5, where 10 is expected for no signal.
- 28 CHATRCHYAN 13Q search for H^0 production in the decays $H^0 \rightarrow W^+ W^- \rightarrow \ell\nu\ell\nu$, $\ell\nu q\bar{q}$ and $H^0 \rightarrow ZZ \rightarrow 4\ell$, $\ell\ell\tau\tau$, $\ell\ell\nu\nu$, and $\ell\ell q\bar{q}$ in up to 5.1 fb^{-1} of pp collisions at $E_{\text{cm}} = 7 \text{ TeV}$ and up to 5.3 fb^{-1} at $E_{\text{cm}} = 8 \text{ TeV}$ in the range $m_{H^0} = 145\text{--}1000 \text{ GeV}$. Superseded by KHACHATRYAN 15AW.
- 29 CHATRCHYAN 13X search for $H^0 t\bar{t}$ production followed by $H^0 \rightarrow b\bar{b}$, one top decaying to $\ell\nu$ and the other to either $\ell\nu$ or $q\bar{q}$ in 5.0 fb^{-1} and 5.1 fb^{-1} of pp collisions at $E_{\text{cm}} = 7$ 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 $m_{H^0} = 110\text{--}140 \text{ GeV}$ at 95% CL. The limit for $m_{H^0} = 125 \text{ GeV}$ is 5.8, where 5.2 is expected for no signal.

- 30 CHATRCHYAN 13Y search for H^0 production in the decay $H \rightarrow \gamma\gamma$ in 5.1 fb^{-1} of pp collisions at $E_{\text{cm}} = 7 \text{ TeV}$ and 5.3 fb^{-1} at $E_{\text{cm}} = 8 \text{ TeV}$. The expected exclusion region for no signal is 110–144 GeV at 95% CL.
- 31 CHATRCHYAN 13Y search for H^0 production in the decay $H \rightarrow ZZ^* \rightarrow 4\ell$ in 5.0 fb^{-1} of pp collisions at $E_{\text{cm}} = 7 \text{ TeV}$ and 5.3 fb^{-1} at $E_{\text{cm}} = 8 \text{ TeV}$. The expected exclusion region for no signal is 120–180 GeV at 95% CL.
- 32 CHATRCHYAN 13Y search for H^0 production in the decay $H \rightarrow WW^* \rightarrow \ell\nu\ell\nu$ in 4.9 fb^{-1} of pp collisions at $E_{\text{cm}} = 7 \text{ TeV}$ and 5.3 fb^{-1} at $E_{\text{cm}} = 8 \text{ TeV}$. The expected exclusion region for no signal is 122–160 GeV at 95% CL.
- 33 AAD 12AI search for H^0 production in pp collisions for the final states $H^0 \rightarrow ZZ^*$, $\gamma\gamma$, WW^* , $b\bar{b}$, $\tau\tau$ with $4.6\text{--}4.8 \text{ fb}^{-1}$ at $E_{\text{cm}} = 7 \text{ TeV}$, and $H^0 \rightarrow ZZ^* \rightarrow 4\ell$, $\gamma\gamma$, $WW^* \rightarrow e\nu\mu\nu$ with $5.8\text{--}5.9 \text{ fb}^{-1}$ at $E_{\text{cm}} = 8 \text{ TeV}$. 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 5.9σ is observed at $m_{H^0} = 126 \text{ GeV}$.
- 34 AAD 12AJ search for H^0 production in the decay $H^0 \rightarrow WW^* \rightarrow \ell\nu\ell\nu$ with 4.7 fb^{-1} of pp collisions at $E_{\text{cm}} = 7 \text{ TeV}$. A limit on cross section times branching ratio which corresponds to $(0.2\text{--}10)$ times the expected Standard Model cross section is given for $m_{H^0} = 110\text{--}600 \text{ GeV}$ at 95% CL.
- 35 AAD 12BU search for H^0 production in the decay $H \rightarrow \tau^+\tau^-$ with 4.7 fb^{-1} of pp collisions at $E_{\text{cm}} = 7 \text{ TeV}$. A limit on cross section times branching ratio which is $(2.9\text{--}11.7)$ times larger than the expected Standard Model cross section is given for $m_{H^0} = 100\text{--}150 \text{ GeV}$ at 95% CL.
- 36 AAD 12BZ search for H^0 production in the decay $H \rightarrow ZZ \rightarrow \ell^+\ell^-\nu\bar{\nu}$ with 4.7 fb^{-1} of pp collisions at $E_{\text{cm}} = 7 \text{ TeV}$. A limit on cross section times branching ratio which corresponds to $(0.2\text{--}4)$ times the expected Standard Model cross section is given for $m_{H^0} = 200\text{--}600 \text{ GeV}$ at 95% CL.
- 37 AAD 12CA search for H^0 production in the decay $H \rightarrow ZZ \rightarrow \ell^+\ell^-q\bar{q}$ with 4.7 fb^{-1} of pp collisions at $E_{\text{cm}} = 7 \text{ TeV}$. A limit on cross section times branching ratio which corresponds to $(0.7\text{--}9)$ times the expected Standard Model cross section is given for $m_{H^0} = 200\text{--}600 \text{ GeV}$ at 95% CL.
- 38 AAD 12CN search for associated H^0W and H^0Z production in the channels $W \rightarrow \ell\nu$, $Z \rightarrow \ell^+\ell^-$, $\nu\bar{\nu}$, and $H^0 \rightarrow b\bar{b}$, with 4.7 fb^{-1} of pp collisions at $E_{\text{cm}} = 7 \text{ TeV}$. A limit on cross section times branching ratio which is $(2.5\text{--}5.5)$ times larger than the expected Standard Model cross section is given for $m_{H^0} = 110\text{--}130 \text{ GeV}$ at 95% CL.
- 39 AAD 12CO search for H^0 production in the decay $H \rightarrow WW \rightarrow \ell\nu q\bar{q}$ with 4.7 fb^{-1} of pp collisions at $E_{\text{cm}} = 7 \text{ TeV}$. A limit on cross section times branching ratio which is $(1.9\text{--}10)$ times larger than the expected Standard Model cross section is given for $m_{H^0} = 300\text{--}600 \text{ GeV}$ at 95% CL.
- 40 AAD 12D search for H^0 production with $H \rightarrow ZZ^* \rightarrow 4\ell$ in 4.8 fb^{-1} of pp collisions at $E_{\text{cm}} = 7 \text{ TeV}$ in the mass range $m_{H^0} = 110\text{--}600 \text{ GeV}$. An excess of events over background with a local significance of 2.1σ is observed at 125 GeV.
- 41 AAD 12G search for H^0 production with $H \rightarrow \gamma\gamma$ in 4.9 fb^{-1} of pp collisions at $E_{\text{cm}} = 7 \text{ TeV}$ in the mass range $m_{H^0} = 110\text{--}150 \text{ GeV}$. An excess of events over background with a local significance of 2.8σ is observed at 126.5 GeV.
- 42 AALTONEN 12AK search for associated $H^0t\bar{t}$ production in the decay chain $t\bar{t} \rightarrow WWbb \rightarrow \ell\nu qqbb$ with 9.45 fb^{-1} of $p\bar{p}$ collisions at $E_{\text{cm}} = 1.96 \text{ TeV}$. A limit on cross section times branching ratio which is $(10\text{--}40)$ times larger than the expected Standard Model cross section is given for $m_{H^0} = 100\text{--}150 \text{ GeV}$ at 95% CL. The limit for $m_{H^0} = 125 \text{ GeV}$ is 20.5, where 12.6 is expected.
- 43 AALTONEN 12AM search for H^0 production in inclusive four-lepton final states coming from $H^0 \rightarrow ZZ$, $H^0Z \rightarrow WW^*\ell\ell$, or $H^0Z \rightarrow \tau\tau\ell\ell$, with 9.7 fb^{-1} of $p\bar{p}$ collisions

- at $E_{\text{cm}} = 1.96$ 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.
- 44 AALTONEN 12AN search for H^0 production in the decay $H^0 \rightarrow \gamma\gamma$ with 10 fb^{-1} of $p\bar{p}$ collisions at $E_{\text{cm}} = 1.96$ 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.
- 45 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 $p\bar{p}$ collisions at $E_{\text{cm}} = 1.96$ 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.
- 46 AALTONEN 12Q search for associated $H^0 Z$ production in the final state $H^0 \rightarrow b\bar{b}$, $Z \rightarrow \ell^+\ell^-$ with 9.45 fb^{-1} of $p\bar{p}$ collisions at $E_{\text{cm}} = 1.96$ 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 2.4σ at $m_{H^0} = 135$ GeV.
- 47 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 3.3σ . The local significance at $m_{H^0} = 125$ GeV is 2.8σ , which corresponds to $(\sigma(H^0 W) + \sigma(H^0 Z)) \text{B}(H^0 \rightarrow b\bar{b}) = (0.23_{-0.08}^{+0.09})$ pb, compared to the Standard Model expectation at $m_{H^0} = 125$ GeV of 0.12 ± 0.01 pb.
- 48 ABAZOV 12K search for associated $H^0 Z$ production in the final state $H^0 \rightarrow b\bar{b}$, $Z \rightarrow \nu\bar{\nu}$, and $H^0 W$ production with $W \rightarrow \ell\nu$ (ℓ not identified) with 9.5 fb^{-1} of $p\bar{p}$ collisions at $E_{\text{cm}} = 1.96$ 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.
- 49 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 $E_{\text{cm}} = 7$ 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.
- 50 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.
- 51 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 $E_{\text{cm}} = 7$ 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.
- 52 CHATRCHYAN 12D search for H^0 production with $H \rightarrow ZZ^{(*)} \rightarrow \ell^+\ell^-q\bar{q}$ in 4.6 fb^{-1} of pp collisions at $E_{\text{cm}} = 7$ 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.

- 53 CHATRCHYAN 12E search for H^0 production with $H \rightarrow WW^{(*)} \rightarrow \ell^+ \nu \ell^- \bar{\nu}$ in 4.6 fb^{-1} of pp collisions at $E_{\text{cm}} = 7 \text{ TeV}$ in the mass range $m_{H^0} = 110\text{--}600 \text{ GeV}$.
- 54 CHATRCHYAN 12F search for associated $H^0 W$ and $H^0 Z$ production followed by $W \rightarrow \ell \nu$, $Z \rightarrow \ell^+ \ell^-$, $\nu \bar{\nu}$, and $H^0 \rightarrow b \bar{b}$, in 4.7 fb^{-1} of pp collisions at $E_{\text{cm}} = 7 \text{ TeV}$. 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 $m_{H^0} = 110\text{--}135 \text{ GeV}$ at 95% CL. The best limit is at $m_{H^0} = 110 \text{ GeV}$.
- 55 CHATRCHYAN 12G search for H^0 production with $H \rightarrow \gamma\gamma$ in 4.8 fb^{-1} of pp collisions at $E_{\text{cm}} = 7 \text{ TeV}$ in the mass range $m_{H^0} = 110\text{--}150 \text{ GeV}$. An excess of events over background with a local significance of 3.1σ is observed at 124 GeV .
- 56 CHATRCHYAN 12H search for H^0 production with $H \rightarrow ZZ^{(*)} \rightarrow 4\ell$ in 4.7 fb^{-1} of pp collisions at $E_{\text{cm}} = 7 \text{ TeV}$ in the mass range $m_{H^0} = 110\text{--}600 \text{ GeV}$. Excesses of events over background are observed around 119 , 126 and 320 GeV . The region $m_{H^0} = 114.4\text{--}134 \text{ GeV}$ remains consistent with the expectation for the production of a SM-like Higgs boson.
- 57 CHATRCHYAN 12I search for H^0 production with $H \rightarrow ZZ \rightarrow \ell^+ \ell^- \nu \bar{\nu}$ in 4.6 fb^{-1} of pp collisions at $E_{\text{cm}} = 7 \text{ TeV}$ in the mass range $m_{H^0} = 250\text{--}600 \text{ GeV}$.
- 58 CHATRCHYAN 12K search for H^0 production in the decay $H \rightarrow \tau^+ \tau^-$ with 4.6 fb^{-1} of pp collisions at $E_{\text{cm}} = 7 \text{ TeV}$. 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 $m_{H^0} = 110\text{--}145 \text{ GeV}$ at 95% CL.
- 59 ABAZOV 11G search for H^0 production in 5.4 fb^{-1} of $p\bar{p}$ collisions at $E_{\text{cm}} = 1.96 \text{ TeV}$ in the decay mode $H^0 \rightarrow WW^{(*)} \rightarrow \ell \nu q \bar{q}'$ (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 $m_{H^0} = 115\text{--}200 \text{ GeV}$ at 95% CL. The best limit is at $m_{H^0} = 160 \text{ GeV}$.
- 60 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 $E_{\text{cm}} = 7 \text{ TeV}$. See their Fig. 6 for a limit on cross section times branching ratio for $m_{H^0} = 120\text{--}600 \text{ GeV}$ 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.
- 61 AALTONEN 10F combine searches for H^0 decaying to $W^+ W^-$ in $p\bar{p}$ collisions at $E_{\text{cm}} = 1.96 \text{ TeV}$ with 4.8 fb^{-1} (CDF) and 5.4 fb^{-1} (DØ).
- 62 AALTONEN 10M combine searches for H^0 decaying to $W^+ W^-$ in $p\bar{p}$ collisions at $E_{\text{cm}} = 1.96 \text{ TeV}$ with 4.8 fb^{-1} (CDF) and 5.4 fb^{-1} (DØ) and derive limits $\sigma(p\bar{p} \rightarrow H^0) \cdot \text{B}(H^0 \rightarrow W^+ W^-) < (1.75\text{--}0.38) \text{ pb}$ for $m_H = 120\text{--}165 \text{ GeV}$, 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.
- 63 AALTONEN 09A search for H^0 production in $p\bar{p}$ collisions at $E_{\text{cm}} = 1.96 \text{ TeV}$ in the decay mode $H^0 \rightarrow WW^{(*)} \rightarrow \ell^+ \ell^- \nu \bar{\nu}$. A limit on $\sigma(H^0) \cdot \text{B}(H^0 \rightarrow WW^{(*)})$ between 0.7 and 2.5 pb (95% CL) is given for $m_{H^0} = 110\text{--}200 \text{ GeV}$, which is 1.7–45 times larger than the expected Standard Model cross section. The best limit is obtained for $m_{H^0} = 160 \text{ GeV}$.
- 64 ABAZOV 09U search for $H^0 \rightarrow \tau^+ \tau^-$ with $\tau \rightarrow \text{hadrons}$ in 1 fb^{-1} of $p\bar{p}$ collisions at $E_{\text{cm}} = 1.96 \text{ TeV}$. The production mechanisms include associated $W/Z+H^0$ production, weak boson fusion, and gluon fusion. A limit (95% CL) is given for $m_{H^0} = 105\text{--}145 \text{ GeV}$, which is 20–82 times larger than the expected Standard Model cross section. The limit for $m_{H^0} = 115 \text{ GeV}$ is 29 times larger than the expected Standard Model cross section.

- ⁶⁵ ABAZOV 06 search for Higgs boson production in $p\bar{p}$ collisions at $E_{\text{cm}} = 1.96$ TeV with the decay chain $H^0 \rightarrow WW^* \rightarrow \ell^\pm \nu \ell'^\mp \bar{\nu}$. A limit $\sigma(H^0) \cdot \text{B}(H^0 \rightarrow WW^*) < (5.6\text{--}3.2)$ pb (95 %CL) is given for $m_{H^0} = 120\text{--}200$ GeV, which far exceeds the expected Standard Model cross section.
- ⁶⁶ ABAZOV 060 search for associated $H^0 W$ production in $p\bar{p}$ collisions at $E_{\text{cm}} = 1.96$ 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 $\sigma(H^0 W) \cdot \text{B}(H^0 \rightarrow WW^*) < (3.2\text{--}2.8)$ pb (95 %CL) is given for $m_{H^0} = 115\text{--}175$ 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.

<u>VALUE (GeV)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>
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 $\Delta\alpha_{\text{had}}^{(5)}(m_Z) = 0.02758 \pm 0.00035$. The 95% CL limit is 285 GeV.

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AAD	12G	PRL 108 111803	G. Aad <i>et al.</i>	(ATLAS Collab.)
AAD	12N	EPJ C72 2157	G. Aad <i>et al.</i>	(ATLAS Collab.)
AALTONEN	12AB	PR D85 092001	T. Aaltonen <i>et al.</i>	(CDF Collab.)
AALTONEN	12AK	PRL 109 181802	T. Aaltonen <i>et al.</i>	(CDF Collab.)
AALTONEN	12AM	PR D86 072012	T. Aaltonen <i>et al.</i>	(CDF Collab.)
AALTONEN	12AN	PL B717 173	T. Aaltonen <i>et al.</i>	(CDF Collab.)
AALTONEN	12AQ	PR D86 091101	T. Aaltonen <i>et al.</i>	(CDF and D0 Collabs.)
AALTONEN	12J	PRL 108 181804	T. Aaltonen <i>et al.</i>	(CDF Collab.)
AALTONEN	12Q	PRL 109 111803	T. Aaltonen <i>et al.</i>	(CDF Collab.)
AALTONEN	12R	PRL 109 111804	T. Aaltonen <i>et al.</i>	(CDF Collab.)
AALTONEN	12S	PRL 109 111805	T. Aaltonen <i>et al.</i>	(CDF Collab.)
AALTONEN	12T	PRL 109 071804	T. Aaltonen <i>et al.</i>	(CDF and D0 Collabs.)
AALTONEN	12U	PR D85 012007	T. Aaltonen <i>et al.</i>	(CDF Collab.)
AALTONEN	12X	PR D85 032005	T. Aaltonen <i>et al.</i>	(CDF Collab.)
ABAZOV	12G	PL B710 569	V.M. Abazov <i>et al.</i>	(D0 Collab.)
ABAZOV	12K	PL B716 285	V.M. Abazov <i>et al.</i>	(D0 Collab.)
ABAZOV	12O	PRL 109 121803	V.M. Abazov <i>et al.</i>	(D0 Collab.)
ABAZOV	12P	PRL 109 121804	V.M. Abazov <i>et al.</i>	(D0 Collab.)
ABLIKIM	12	PR D85 092012	M. Ablikim <i>et al.</i>	(BES III Collab.)
BAAK	12	EPJ C72 2003	M. Baak <i>et al.</i>	(Gfitter Group)
BAAK	12A	EPJ C72 2205	M. Baak <i>et al.</i>	(Gfitter Group)
CHATRCHYAN	12AO	JHEP 1209 111	S. Chatrchyan <i>et al.</i>	(CMS Collab.)
CHATRCHYAN	12AY	JHEP 1211 088	S. Chatrchyan <i>et al.</i>	(CMS Collab.)
CHATRCHYAN	12C	JHEP 1203 081	S. Chatrchyan <i>et al.</i>	(CMS Collab.)
CHATRCHYAN	12D	JHEP 1204 036	S. Chatrchyan <i>et al.</i>	(CMS Collab.)
CHATRCHYAN	12E	PL B710 91	S. Chatrchyan <i>et al.</i>	(CMS Collab.)
CHATRCHYAN	12F	PL B710 284	S. Chatrchyan <i>et al.</i>	(CMS Collab.)
CHATRCHYAN	12G	PL B710 403	S. Chatrchyan <i>et al.</i>	(CMS Collab.)
CHATRCHYAN	12H	PRL 108 111804	S. Chatrchyan <i>et al.</i>	(CMS Collab.)
CHATRCHYAN	12I	JHEP 1203 040	S. Chatrchyan <i>et al.</i>	(CMS Collab.)
CHATRCHYAN	12K	PL B713 68	S. Chatrchyan <i>et al.</i>	(CMS Collab.)
CHATRCHYAN	12N	PL B716 30	S. Chatrchyan <i>et al.</i>	(CMS Collab.)
CHATRCHYAN	12V	PRL 109 121801	S. Chatrchyan <i>et al.</i>	(CMS Collab.)
AALTONEN	11P	PRL 107 031801	T. Aaltonen <i>et al.</i>	(CDF Collab.)
ABAZOV	11G	PRL 106 171802	V.M. Abazov <i>et al.</i>	(D0 Collab.)
ABAZOV	11K	PL B698 97	V.M. Abazov <i>et al.</i>	(D0 Collab.)
ABAZOV	11W	PRL 107 121801	V.M. Abazov <i>et al.</i>	(D0 Collab.)
ABOUZAID	11A	PRL 107 201803	E. Abouzaid <i>et al.</i>	(KTeV Collab.)
CHATRCHYAN	11J	PL B699 25	S. Chatrchyan <i>et al.</i>	(CMS Collab.)
DEL-AMO-SA...	11J	PRL 107 021804	P. del Amo Sanchez <i>et al.</i>	(BABAR Collab.)
LEES	11H	PRL 107 221803	J.P. Lees <i>et al.</i>	(BABAR Collab.)

AALTONEN	10F	PRL 104 061802	T. Aaltonen <i>et al.</i>	(CDF and D0 Collabs.)
AALTONEN	10M	PR D82 011102	T. Aaltonen <i>et al.</i>	(CDF and D0 Collabs.)
ABBIENDI	10	PL B682 381	G. Abbiendi <i>et al.</i>	(OPAL Collab.)
ANDREAS	10	JHEP 1008 003	S. Andreas <i>et al.</i>	(DESY)
ERLER	10A	PR D81 051301	J. Erler	(UNAM)
HYUN	10	PRL 105 091801	H.J. Hyun <i>et al.</i>	(BELLE Collab.)
SCHAEEL	10	JHEP 1005 049	S. Schaeel <i>et al.</i>	(ALEPH Collab.)
AALTONEN	09A	PRL 102 021802	T. Aaltonen <i>et al.</i>	(CDF Collab.)
AALTONEN	09AB	PRL 103 061803	T. Aaltonen <i>et al.</i>	(CDF Collab.)
AALTONEN	09AR	PRL 103 201801	T. Aaltonen <i>et al.</i>	(CDF Collab.)
ABAZOV	09U	PRL 102 251801	V.M. Abazov <i>et al.</i>	(D0 Collab.)
ABAZOV	09V	PRL 103 061801	V.M. Abazov <i>et al.</i>	(D0 Collab.)
AUBERT	09P	PRL 103 181801	B. Aubert <i>et al.</i>	(BABAR Collab.)
AUBERT	09Z	PRL 103 081803	B. Aubert <i>et al.</i>	(BABAR Collab.)
TUNG	09	PRL 102 051802	Y.C. Tung <i>et al.</i>	(KEK E391a Collab.)
ABAZOV	08U	PRL 101 051801	V.M. Abazov <i>et al.</i>	(D0 Collab.)
ABDALLAH	08B	EPJ C54 1	J. Abdallah <i>et al.</i>	(DELPHI Collab.)
Also		EPJ C56 165 (errat.)	J. Abdallah <i>et al.</i>	(DELPHI Collab.)
LOVE	08	PRL 101 151802	W. Love <i>et al.</i>	(CLEO Collab.)
ABBIENDI	07	EPJ C49 457	G. Abbiendi <i>et al.</i>	(OPAL Collab.)
BESSON	07	PRL 98 052002	D. Besson <i>et al.</i>	(CLEO Collab.)
SCHAEEL	07	EPJ C49 439	S. Schaeel <i>et al.</i>	(ALEPH Collab.)
ABAZOV	06	PRL 96 011801	V.M. Abazov <i>et al.</i>	(D0 Collab.)
ABAZOV	06O	PRL 97 151804	V.M. Abazov <i>et al.</i>	(D0 Collab.)
LEP-SLC	06	PRPL 427 257	ALEPH, DELPHI, L3, OPAL, SLD and working groups	
SCHAEEL	06B	EPJ C47 547	S. Schaeel <i>et al.</i>	(LEP Collabs.)
ABBIENDI	05A	EPJ C40 317	G. Abbiendi <i>et al.</i>	(OPAL Collab.)
ABDALLAH	05D	EPJ C44 147	J. Abdallah <i>et al.</i>	(DELPHI Collab.)
ACHARD	05	PL B609 35	P. Achard <i>et al.</i>	(L3 Collab.)
ACOSTA	05Q	PR D72 072004	D. Acosta <i>et al.</i>	(CDF Collab.)
PARK	05	PRL 94 021801	H.K. Park <i>et al.</i>	(FNAL HyperCP Collab.)
ABBIENDI	04K	PL B597 11	G. Abbiendi <i>et al.</i>	(OPAL Collab.)
ABBIENDI	04M	EPJ C37 49	G. Abbiendi <i>et al.</i>	(OPAL Collab.)
ABDALLAH	04	EPJ C32 145	J. Abdallah <i>et al.</i>	(DELPHI Collab.)
ABDALLAH	04B	EPJ C32 475	J. Abdallah <i>et al.</i>	(DELPHI Collab.)
ABDALLAH	04L	EPJ C35 313	J. Abdallah <i>et al.</i>	(DELPHI Collab.)
ABDALLAH	04O	EPJ C38 1	J. Abdallah <i>et al.</i>	(DELPHI Collab.)
ACHARD	04B	PL B583 14	P. Achard <i>et al.</i>	(L3 Collab.)
ACHARD	04F	PL B589 89	P. Achard <i>et al.</i>	(L3 Collab.)
ABBIENDI	03B	EPJ C26 479	G. Abbiendi <i>et al.</i>	(OPAL Collab.)
ABBIENDI	03F	EPJ C27 311	G. Abbiendi <i>et al.</i>	(OPAL Collab.)
ABBIENDI	03G	EPJ C27 483	G. Abbiendi <i>et al.</i>	(OPAL Collab.)
ACHARD	03C	PL B568 191	P. Achard <i>et al.</i>	(L3 Collab.)
CARENA	03	EPJ C26 601	M.S. Carena <i>et al.</i>	
HEISTER	03D	PL B565 61	A. Heister <i>et al.</i>	(ALEPH, DELPHI, L3+)
ALEPH, DELPHI, L3, OPAL, LEP Higgs Working Group				
ABBIENDI	02D	EPJ C23 397	G. Abbiendi <i>et al.</i>	(OPAL Collab.)
ABBIENDI	02F	PL B544 44	G. Abbiendi <i>et al.</i>	(OPAL Collab.)
ACHARD	02C	PL B534 28	P. Achard <i>et al.</i>	(L3 Collab.)
ACHARD	02H	PL B545 30	P. Achard <i>et al.</i>	(L3 Collab.)
AKERROYD	02	PR D66 037702	A.G. Akeroyd <i>et al.</i>	
HEISTER	02	PL B526 191	A. Heister <i>et al.</i>	(ALEPH Collab.)
HEISTER	02L	PL B544 16	A. Heister <i>et al.</i>	(ALEPH Collab.)
HEISTER	02M	PL B544 25	A. Heister <i>et al.</i>	(ALEPH Collab.)
ABBIENDI	01E	EPJ C18 425	G. Abbiendi <i>et al.</i>	(OPAL Collab.)
ABREU	01F	PL B507 89	P. Abreu <i>et al.</i>	(DELPHI Collab.)
ACHARD	01C	PL B517 319	P. Achard <i>et al.</i>	(L3 Collab.)
AFFOLDER	01H	PR D64 092002	T. Affolder <i>et al.</i>	(CDF Collab.)
BARATE	01C	PL B499 53	R. Barate <i>et al.</i>	(ALEPH Collab.)
ACCIARRI	00M	PL B485 85	M. Acciarri <i>et al.</i>	(L3 Collab.)
ACCIARRI	00R	PL B489 102	M. Acciarri <i>et al.</i>	(L3 Collab.)
ACCIARRI	00S	PL B489 115	M. Acciarri <i>et al.</i>	(L3 Collab.)
BARATE	00L	PL B487 241	R. Barate <i>et al.</i>	(ALEPH Collab.)
ABBIENDI	99E	EPJ C7 407	G. Abbiendi <i>et al.</i>	(OPAL Collab.)
ABBIENDI	99O	PL B464 311	G. Abbiendi <i>et al.</i>	(OPAL Collab.)
ABBOTT	99B	PRL 82 2244	B. Abbott <i>et al.</i>	(D0 Collab.)
ABREU	99P	PL B458 431	P. Abreu <i>et al.</i>	(DELPHI Collab.)
CARENA	99B	hep-ph/9912223	M.S. Carena <i>et al.</i>	
CERN-TH/99-374				
ABBOTT	98	PRL 80 442	B. Abbott <i>et al.</i>	(D0 Collab.)
ACKERSTAFF	98S	EPJ C5 19	K. Ackerstaff <i>et al.</i>	(OPAL Collab.)

ACKERSTAFF	98Y	PL B437 218	K. Ackerstaff <i>et al.</i>	(OPAL Collab.)
GONZALEZ...	98B	PR D57 7045	M.C. Gonzalez-Garcia, S.M. Lietti, S.F. Novaes	
PDG	98	EPJ C3 1	C. Caso <i>et al.</i>	(PDG Collab.)
KRAWCZYK	97	PR D55 6968	M. Krawczyk, J. Zochowski	(WARS)
ALEXANDER	96H	ZPHY C71 1	G. Alexander <i>et al.</i>	(OPAL Collab.)
PDG	96	PR D54 1	R. M. Barnett <i>et al.</i>	(PDG Collab.)
ABREU	95H	ZPHY C67 69	P. Abreu <i>et al.</i>	(DELPHI Collab.)
BALEST	95	PR D51 2053	R. Balest <i>et al.</i>	(CLEO Collab.)
PICH	92	NP B388 31	A. Pich, J. Prades, P. Yepes	(CERN, CPPM)
ANTREASYAN	90C	PL B251 204	D. Antreasyan <i>et al.</i>	(Crystal Ball Collab.)
