

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.

The observed signal at about 125 GeV, see section “H”, can be interpreted as one of the neutral Higgs bosons of supersymmetric models. Unless otherwise noted, we identify the lighter scalar H_1^0 with the Higgs discovered at 125 GeV at the LHC (AAD 12AI, CHATRCHYAN 12N).

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 $b\bar{b}\tau^+\tau^-$. Unless otherwise stated, the following results assume no invisible H_1^0 or A^0 decays. Unless otherwise noted, the results are given in the m_h^{max} scenario, CARENA 13.

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 \tilde{t} 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 beyond (SLAVICH 21), and the results are given for the M_h^{125} benchmark scenario, see BAGNASCHI 19.

Mass Limits for heavy neutral Higgs bosons (H_2^0, A^0) in the MSSM

The limits rely on $pp \rightarrow H_2^0/A^0 \rightarrow \tau^+\tau^-$ and assume that H_2^0 and A^0 are (sufficiently) mass degenerate. The limits depend on $\tan\beta$.

VALUE (GeV)	CL%	DOCUMENT ID	TECN	COMMENT
> 835	95	1 TUMASYAN	23S CMS	$\tan\beta = 10$ GeV
>1240	95	1 TUMASYAN	23S CMS	$\tan\beta = 20$ GeV
>1605	95	1 TUMASYAN	23S CMS	$\tan\beta = 30$ GeV
>1820	95	1 TUMASYAN	23S CMS	$\tan\beta = 40$ GeV
>1950	95	1 TUMASYAN	23S CMS	$\tan\beta = 50$ GeV
>2062	95	1 TUMASYAN	23S CMS	$\tan\beta = 60$ GeV
>1121	95	2 AAD	20AA ATLS	$\tan\beta = 10$ GeV
>1475	95	2 AAD	20AA ATLS	$\tan\beta = 20$ GeV
>1677	95	2 AAD	20AA ATLS	$\tan\beta = 30$ GeV
>1826	95	2 AAD	20AA ATLS	$\tan\beta = 40$ GeV
>1937	95	2 AAD	20AA ATLS	$\tan\beta = 50$ GeV
>2033	95	2 AAD	20AA ATLS	$\tan\beta = 60$ GeV
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●				
		3 CHEKHOVSKY25C	CMS	$H_2^0/A^0 \rightarrow b\bar{b}$
		4 CHEKHOVSKY25I	CMS	$A^0 \rightarrow ZH$
		5 AAD	24AP ATLS	$H_2^0, A^0 \rightarrow t\bar{t}$
		6 AAD	24CB ATLS	H properties
		7 AAD	24H ATLS	$H_2^0 \rightarrow HH$
		8 AAD	20 ATLS	H properties
		9 AAD	20C ATLS	$H_2^0 \rightarrow HH$
		10 AAD	20L ATLS	$H_2^0 \rightarrow b\bar{b}$
		11 SIRUNYAN	20AC CMS	$A^0 \rightarrow ZH$
		12 SIRUNYAN	20AF CMS	$H_2^0/A^0 \rightarrow t\bar{t}$
		13 SIRUNYAN	20Y CMS	$H_2^0 \rightarrow W^+W^-$
		14 SIRUNYAN	19CR CMS	$H_2^0/A^0 \rightarrow \mu^+\mu^-$
> 377	95	15 AABOUD	18G ATLS	$\tan\beta = 10$ GeV
> 863	95	15 AABOUD	18G ATLS	$\tan\beta = 20$ GeV
>1157	95	15 AABOUD	18G ATLS	$\tan\beta = 30$ GeV
>1328	95	15 AABOUD	18G ATLS	$\tan\beta = 40$ GeV
>1483	95	15 AABOUD	18G ATLS	$\tan\beta = 50$ GeV
>1613	95	15 AABOUD	18G ATLS	$\tan\beta = 60$ GeV
		16 SIRUNYAN	18A CMS	$H_2^0 \rightarrow H^0H^0$
		17 SIRUNYAN	18BP CMS	$pp \rightarrow H_2^0/A^0 + b + X,$ $H_2^0/A^0 \rightarrow b\bar{b}$
> 389	95	18 SIRUNYAN	18CX CMS	$\tan\beta = 10$ GeV
> 832	95	18 SIRUNYAN	18CX CMS	$\tan\beta = 20$ GeV
>1148	95	18 SIRUNYAN	18CX CMS	$\tan\beta = 30$ GeV
>1341	95	18 SIRUNYAN	18CX CMS	$\tan\beta = 40$ GeV
>1496	95	18 SIRUNYAN	18CX CMS	$\tan\beta = 50$ GeV

>1613	95	18 SIRUNYAN	18CX CMS	$\tan\beta = 60 \text{ GeV}$
		19 AABOUD	16AA ATLS	$A^0 \rightarrow \tau^+ \tau^-$
		20 KHACHATRY...	16A CMS	$H_{1,2}^0/A^0 \rightarrow \mu^+ \mu^-$
		21 KHACHATRY...	16P CMS	$H_2^0 \rightarrow H^0 H^0, A^0 \rightarrow Z H^0$
		22 KHACHATRY...	15AY CMS	$pp \rightarrow H_{1,2}^0/A^0 + b + X,$ $H_{1,2}^0/A^0 \rightarrow b\bar{b}$
		23 AAD	14AW ATLS	$pp \rightarrow H_{1,2}^0/A^0 + X,$ $H_{1,2}^0/A^0 \rightarrow \tau\tau$
		24 KHACHATRY...	14M CMS	$pp \rightarrow H_{1,2}^0/A^0 + X,$ $H_{1,2}^0/A^0 \rightarrow \tau\tau$
		25 AAD	13O ATLS	$pp \rightarrow H_{1,2}^0/A^0 + X,$ $H_{1,2}^0/A^0 \rightarrow \tau^+ \tau^-,$ $\mu^+ \mu^-$
		26 AAIJ	13T LHCb	$pp \rightarrow H_{1,2}^0/A^0 + X,$ $H_{1,2}^0/A^0 \rightarrow \tau^+ \tau^-$
		27 CHATRCHYAN	13AG CMS	$pp \rightarrow H_{1,2}^0/A^0 + b + X,$ $H_{1,2}^0/A^0 \rightarrow b\bar{b}$
		28 AALTONEN	12AQ TEVA	$p\bar{p} \rightarrow H_{1,2}^0/A^0 + b + X,$ $H_{1,2}^0/A^0 \rightarrow b\bar{b}$
		29 AALTONEN	12X CDF	$p\bar{p} \rightarrow H_{1,2}^0/A^0 + b + X,$ $H_{1,2}^0/A^0 \rightarrow b\bar{b}$
		30 ABAZOV	12G D0	$p\bar{p} \rightarrow H_{1,2}^0/A^0 + X,$ $H_{1,2}^0/A^0 \rightarrow \tau^+ \tau^-$
		31 CHATRCHYAN	12K CMS	$pp \rightarrow H_{1,2}^0/A^0 + X,$ $H_{1,2}^0/A^0 \rightarrow \tau^+ \tau^-$
		32 ABAZOV	11K D0	$p\bar{p} \rightarrow H_{1,2}^0/A^0 + b + X,$ $H_{1,2}^0/A^0 \rightarrow b\bar{b}$
		33 ABAZOV	11W D0	$p\bar{p} \rightarrow H_{1,2}^0/A^0 + b + X,$ $H_{1,2}^0/A^0 \rightarrow \tau^+ \tau^-$
		34 AALTONEN	09AR CDF	$p\bar{p} \rightarrow H_{1,2}^0/A^0 + X,$ $H_{1,2}^0/A^0 \rightarrow \tau^+ \tau^-$
> 90.4		35 ABDALLAH	08B DLPH	$E_{\text{cm}} \leq 209 \text{ GeV}$
> 93.4	95	36 SCHAELE	06B LEP	$E_{\text{cm}} \leq 209 \text{ GeV}$
		37 ACOSTA	05Q CDF	$p\bar{p} \rightarrow H_{1,2}^0/A^0 + X$
> 85.0	95	38,39 ABBIENDI	04M OPAL	$E_{\text{cm}} \leq 209 \text{ GeV}$
		40 ABBIENDI	03G OPAL	$H_1^0 \rightarrow A^0 A^0$
> 86.5	95	38,41 ACHARD	02H L3	$E_{\text{cm}} \leq 209 \text{ GeV}, \tan\beta > 0.4$
		42 AKEROYD	02 RVUE	
> 90.1	95	38,43 HEISTER	02 ALEP	$E_{\text{cm}} \leq 209 \text{ GeV}, \tan\beta > 0.5$

- 1 TUMASYAN 23S search for production of $H_2^0/A^0 \rightarrow \tau^+\tau^-$ by gluon fusion and b -associated production using 138 fb^{-1} of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$. See their Fig. 13 for excluded regions in the m_{A^0} - $\tan\beta$ plane in M_h^{125} and M_{hEFT}^{125} MSSM scenarios. In both scenarios $m_{A^0} < 350 \text{ GeV}$ is excluded at 95% CL.
- 2 AAD 20AA search for $H_2^0/A^0 \rightarrow \tau^+\tau^-$ produced by gluon fusion or b -associated production using 139 fb^{-1} of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$. See their Fig. 2(c) for excluded region in the M_h^{125} scenario of MSSM. Values of $\tan\beta > 8$ (21) are excluded for $m_{A^0} = 1.0$ (1.5) TeV at 95%CL.
- 3 CHEKHOVSKY 25C search for $H_2^0/A^0 \rightarrow b\bar{b}$ by b -associated production using 36.7 – 126.9 fb^{-1} of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$. See their Figs. 16–18 for excluded regions in the m_{A^0} - $\tan\beta$ plane in various MSSM scenarios.
- 4 CHEKHOVSKY 25I search for production of an A^0 in gluon-gluon fusion and in association with a $b\bar{b}$, decaying to ZH in the final states $\ell^+\ell^-\tau^+\tau^-$, assuming $B(H \rightarrow \tau^+\tau^-)$ of the SM, using 138 fb^{-1} of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$. See their Fig. 7 for excluded parameter region in M_{hEFT}^{125} MSSM scenario.
- 5 AAD 24AP search for production of a heavy H_2^0 and A^0 decaying to $t\bar{t}$ in 140 fb^{-1} of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$. See their Fig. 13(b) for excluded parameter regions in hMSSM.
- 6 AAD 24CB use ATLAS measurements from up to 139 fb^{-1} of H production cross sections and decays to constrain the MSSM Higgs sector. See their Figs. 22 and 23 for excluded regions in various MSSM scenarios.
- 7 AAD 24H combine searches for a scalar resonance decaying to HH using up to 139 fb^{-1} of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$ from AAD 22F, AAD 23Z, and AAD 22Y. See their Fig. 3 for the excluded region in the MSSM $M_{h,EFT}^{125}$ and $M_{h,EFT}^{125}(\tilde{\chi})$ benchmark scenarios (where only the resonant H-exchange contribution has been taken into account in the signal modelling).
- 8 AAD 20 combine measurements on H production and decay using data taken in years 2015–2017 (up to 79.8 fb^{-1}) of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$. See their Fig. 19 for excluded region in the hMSSM parameter space.
- 9 AAD 20C combine searches for a scalar resonance decaying to HH in 36.1 fb^{-1} of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$ from AABOUD 19A, AABOUD 190, AABOUD 18CQ, AABOUD 19T, AABOUD 18CW, and AABOUD 18BU. See their Fig. 7(b) for the excluded region in the hMSSM parameter space.
- 10 AAD 20L search for b -associated production of H_2^0 decaying to $b\bar{b}$ in 27.8 fb^{-1} of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$. See their Fig. 9 for excluded regions in hMSSM, $m_h^{\text{mod}+}$ and $m_h^{\text{mod}-}$ scenarios of MSSM.
- 11 SIRUNYAN 20AC search for gluon-fusion and b -associated production of A^0 decaying to ZH in 35.9 fb^{-1} of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$. See their Fig. 6 for excluded regions in the M_{hEFT}^{125} and hMSSM scenarios of the MSSM.
- 12 SIRUNYAN 20AF search for $H_2^0/A^0 \rightarrow t\bar{t}$ with one or two charged leptons in the final state using kinematic variables in 35.9 fb^{-1} of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$. See their Fig. 8 for excluded region in the hMSSM scenario of MSSM. Values of $\tan\beta$ below 1.0–1.5 are excluded for $m_{A^0} = 0.4$ – 0.75 TeV at 95%CL.
- 13 SIRUNYAN 20Y search for gluon-fusion and vector-boson-fusion production of H_2^0 decaying to W^+W^- in the final states $\ell\nu\ell\nu$ and $\ell\nu qq$ in 35.9 fb^{-1} of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$. See their Figs. 8 and 9 for excluded regions in various MSSM scenarios.
- 14 SIRUNYAN 19CR search for production of H_2^0/A^0 in gluon fusion and in association with a $b\bar{b}$ pair, decaying to $\mu^+\mu^-$ in 35.9 fb^{-1} of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$. See

- their Fig. 5 for the excluded region in the MSSM parameter space in the $m_h^{\text{mod}+}$ and hMSSM scenarios.
- 15 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 $E_{\text{cm}} = 13 \text{ TeV}$. See their Fig. 10 for excluded regions in the $m_{A^0} - \tan\beta$ plane in several MSSM scenarios.
 - 16 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 $E_{\text{cm}} = 13 \text{ TeV}$. See their Fig. 5 (lower) for excluded regions in the $m_{A^0} - \tan\beta$ plane in the hMSSM scenario.
 - 17 SIRUNYAN 18BP search for production of $H_2^0/A^0 \rightarrow b\bar{b}$ by b -associated production in 35.7 fb^{-1} of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$. See their Fig. 6 for the limits on cross section times branching ratio for $m_{H_2^0}, m_{A^0} = 0.3\text{--}1.3 \text{ TeV}$, and Fig. 7 for excluded regions in the $m_{A^0} - \tan(\beta)$ plane in several MSSM scenarios.
 - 18 SIRUNYAN 18CX search for production of $H_{1,2}^0/A^0 \rightarrow \tau^+\tau^-$ by gluon fusion and b -associated production in 35.9 fb^{-1} of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$. See their Fig. 9 for excluded regions in the $m_{A^0} - \tan(\beta)$ plane in several MSSM scenarios.
 - 19 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 $E_{\text{cm}} = 13 \text{ TeV}$. See their Fig. 5(a, b) for limits on cross section times branching ratio for $m_{A^0} = 200\text{--}1200 \text{ GeV}$, and Fig. 5(c, d) for the excluded region in the MSSM parameter space in the $m_h^{\text{mod}+}$ and hMSSM scenarios.
 - 20 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.
 - 21 KHACHATRYAN 16P search for gluon fusion production of an H_2^0 decaying to $H^0 H^0 \rightarrow b\bar{b}\tau^+\tau^-$ 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 $m_{H_2^0} = m_{A^0} = 300 \text{ GeV}$.
 - 22 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.
 - 23 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.
 - 24 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.

- 25 AAD 130 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.
- 26 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.
- 27 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 18–42 at 95% CL are obtained in the m_h^{max} scenario with $\mu = +200\text{ GeV}$.
- 28 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.
- 29 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.
- 30 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.
- 31 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.
- 32 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 $\mu = -200\text{ GeV}$.
- 33 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.
- 34 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.
- 35 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.
- 36 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 $\sigma(H_1^0 H_2^0) \cdot B(H_1^0, H_2^0 \rightarrow b\bar{b}, \tau^+\tau^-)$.
- 37 ACOSTA 05Q search for $H_{1,2}^0/A^0$ production in $p\bar{p}$ collisions at $E_{\text{cm}} = 1.8$ TeV with $H_{1,2}^0/A^0 \rightarrow \tau^+\tau^-$. At $m_{A^0} = 100$ GeV, the obtained cross section upper limit is above theoretical expectation.
- 38 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.
- 39 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.
- 40 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 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.
- 41 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.
- 42 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.
- 43 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 H_1^0 (Higgs Boson) in Supersymmetric Models

VALUE (GeV)	CL%	DOCUMENT ID	TECN	COMMENT
>89.7		¹ ABDALLAH 08B	DLPH	$E_{\text{cm}} \leq 209$ GeV
>92.8	95	² SCHAEEL 06B	LEP	$E_{\text{cm}} \leq 209$ GeV
>84.5	95	^{3,4} ABBIENDI 04M	OPAL	$E_{\text{cm}} \leq 209$ GeV
>86.0	95	^{3,5} ACHARD 02H	L3	$E_{\text{cm}} \leq 209$ GeV, $\tan\beta > 0.4$
>89.8	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. • • •

$$\begin{aligned} &^7 \text{AALTONEN 12AQ TEVA } p\bar{p} \rightarrow H_{1,2}^0/A^0 + b + X, \\ &H_{1,2}^0/A^0 \rightarrow b\bar{b} \end{aligned}$$

- 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 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.

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”, can be interpreted as one of the neutral Higgs bosons of an extended Higgs sector.

Mass Limits in General two-Higgs-doublet Models

VALUE (GeV)	CL%	DOCUMENT ID	TECN	COMMENT
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●				
		1 AAD	25AL ATLS	$t\bar{t}H_2^0/A^0$
		2 CHEKHOVSKY25c	CMS	$H_2^0/A^0 \rightarrow b\bar{b}$
		3 HAYRAPETY...25I	CMS	$A^0 \rightarrow ZH_2^0, H_2^0 \rightarrow t\bar{t}$
		4 AAD	24AB ATLS	$A^0 \rightarrow ZH_2^0$
		5 AAD	24AP ATLS	$H_2^0, A^0 \rightarrow t\bar{t}$
		6 AAD	24CB ATLS	H properties
		7 AAD	24H ATLS	$H_2^0 \rightarrow HH$
		8 HAYRAPETY...24H	CMS	flavor changing H_2^0, A^0
		9 AAD	23AD ATLS	$A^0 \rightarrow ZH_2^0, H_2^0 \rightarrow HH$
		10 AAD	23BG ATLS	$t\bar{t}H_2^0/A^0$
		11 AAD	23O ATLS	$A^0 \rightarrow ZH$
		12 AAD	21AF ATLS	$H_2^0 \rightarrow ZZ$
		13 AAD	21AI ATLS	$A^0 \rightarrow ZH_2^0$
		14 AAD	20 ATLS	H^0 properties
		15 AAD	20L ATLS	$H_2^0 \rightarrow b\bar{b}$
		16 SIRUNYAN	20AA CMS	$H_2^0 \rightarrow ZA^0$ or $A^0 \rightarrow ZH_2^0$
		17 SIRUNYAN	20Y CMS	$H_2^0 \rightarrow W^+W^-$
		18 SIRUNYAN	19AE CMS	$A^0 \rightarrow \tau^+\tau^-$
		19 SIRUNYAN	19AV CMS	$A^0 \rightarrow ZH^0$
		20 AABOUD	18AH ATLS	$A^0 \rightarrow ZH_2^0$
		21 AABOUD	18AI ATLS	$A^0 \rightarrow ZH^0$

		22	AABOUD	18BF ATLS	$H_2^0 \rightarrow ZZ$
		23	AABOUD	18CE ATLS	$pp \rightarrow H_2^0/A^0 t\bar{t}$, $H_2^0/A^0 \rightarrow t\bar{t}$
		24	HALLER	18 RVUE	global fits
		25	SIRUNYAN	18BP CMS	$pp \rightarrow H_2^0/A^0 + b + X$, $H_2^0/A^0 \rightarrow b\bar{b}$
		26	SIRUNYAN	18ED CMS	$A^0 \rightarrow ZH^0$
		27	AABOUD	17AN ATLS	$H_2^0, A^0 \rightarrow t\bar{t}$
		28	SIRUNYAN	17AX CMS	$A^0 b\bar{b}, A^0 \rightarrow \mu^+ \mu^-$
		29	AAD	16AX ATLS	$H_2^0 \rightarrow ZZ$
		30	KHACHATRY...16P	CMS	$H_2^0 \rightarrow H^0 H^0, A^0 \rightarrow ZH^0$
		31	KHACHATRY...16W	CMS	$A^0 b\bar{b}, A^0 \rightarrow \tau^+ \tau^-$
		32	KHACHATRY...16Z	CMS	$H_2^0 \rightarrow ZA^0$ or $A^0 \rightarrow ZH_2^0$
		33	AAD	15BK ATLS	$H_2^0 \rightarrow H^0 H^0$
		34	AAD	15S ATLS	$A^0 \rightarrow ZH^0$
		35	KHACHATRY...15BB	CMS	$H_2^0, A^0 \rightarrow \gamma\gamma$
		36	KHACHATRY...15N	CMS	$A^0 \rightarrow ZH^0$
		37	AAD	14M ATLS	$H_2^0 \rightarrow H^\pm W^\mp \rightarrow$ $H^0 W^\pm W^\mp, H^0 \rightarrow b\bar{b}$
		38	KHACHATRY...14Q	CMS	$H_2^0 \rightarrow H^0 H^0, A^0 \rightarrow ZH^0$
		39	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 >110.6	95	40	ABBIENDI	05A OPAL	H_1^0 , Type II model
	95	41	ABDALLAH	05D DLPH	$H^0 \rightarrow 2 \text{ jets}$
		42	ABDALLAH	04O DLPH	$Z \rightarrow f\bar{f}H$
		43	ABDALLAH	04O DLPH	$e^+ e^- \rightarrow H^0 Z, H^0 A^0$
		44	ABBIENDI	02D OPAL	$e^+ e^- \rightarrow b\bar{b}H$
none 1–44 > 68.0	95	45	ABBIENDI	01E OPAL	H_1^0 , Type-II model
	95	46	ABBIENDI	99E OPAL	$\tan\beta > 1$
		47	ABREU	95H DLPH	$Z \rightarrow H^0 Z^*, H^0 A^0$
		48	PICH	92 RVUE	Very light Higgs

¹ AAD 25AL search for production of H_2^0/A^0 in association with a $t\bar{t}$ pair, decaying to $t\bar{t}$, resulting in final states with one lepton or two opposite-sign leptons, using 139 fb^{-1} of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$. See their Fig. 9 for excluded regions in the parameter space of the type II 2HDM. Combined limits with AAD 23BG are shown in Fig. 11.

² CHEKHOVSKY 25C search for $H_2^0/A^0 \rightarrow b\bar{b}$ by b -associated production using $36.7\text{--}126.9 \text{ fb}^{-1}$ of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$. See their Figs. 19 and 20 for excluded regions in the parameter space in Type II and flipped 2HDMs.

³ HAYRAPETYAN 25I search for $A^0 \rightarrow ZH_2^0$ with $H_2^0 \rightarrow t\bar{t}$ using 138 fb^{-1} of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$. See their Figs. 6 and 7 for excluded regions the 2HDM Type II.

⁴ AAD 24AB search for gluon-fusion and $b\bar{b}$ associated production of A^0 decaying to $A^0 \rightarrow ZH_2^0$, in the final states $\ell^+ \ell^- t\bar{t}$ and $\nu\bar{\nu} b\bar{b}$ using 140 fb^{-1} of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$. See their Figs. 5 and 6 for limits on cross section times branching ratios in terms of two-Higgs-doublet models, and Fig. 7 for excluded model parameter space.

- 5 AAD 24AP search for production of a heavy H_2^0 and A^0 decaying to $t\bar{t}$ in 140 fb^{-1} of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$. See their Fig. 13(a) for excluded parameter regions in a Type II two-Higgs-doublet model.
- 6 AAD 24CB use ATLAS measurements from up to 139 fb^{-1} of H production cross sections and decays to constrain two Higgs doublet models. See their Figs. 19–21 for excluded regions of 2HDM parameter space.
- 7 AAD 24H combine searches for a scalar resonance decaying to HH using up to 139 fb^{-1} of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$ from AAD 22F, AAD 23Z, and AAD 22Y. See their Fig. 2 for the excluded region in the Type-I two-Higgs-doublet model parameter space (where only the resonant H-exchange contribution has been taken into account in the signal modelling).
- 8 HAYRAPETYAN 24H search for H_2^0 and A^0 having flavor-violating couplings to tc or tu , produced in association with top quark(s), using 138 fb^{-1} of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$. For the interpretation of the data in terms of flavor-violating two-Higgs-doublet models, given in the range $m_{A^0} = 0.2\text{--}1.0 \text{ TeV}$, see their Figs. 4, 5, and 6.
- 9 AAD 23AD search for associated production of W/ZH_2^0 and gluon fusion production of A^0 decaying to ZH_2^0 , with the decay chain $H_2^0 \rightarrow HH \rightarrow b\bar{b}b\bar{b}$, using 139 fb^{-1} of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$. See their Figs. 12 and 13 for excluded regions in Type-I and lepton-specific 2HDMs.
- 10 AAD 23BG search for production of H_2^0/A^0 in association with a $t\bar{t}$ pair, decaying to $t\bar{t}$, resulting in final states with two same-sign leptons or three or more leptons, using 139 fb^{-1} of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$. See their Fig. 8 (corrected version in the erratum) for excluded regions in the parameter space of the type II 2HDM.
- 11 AAD 23O search for production of an A^0 in gluon-gluon fusion and in association with a $b\bar{b}$, decaying to ZH in the final states $\nu\bar{\nu}b\bar{b}$ and $\ell^+\ell^-b\bar{b}$ using 139 fb^{-1} of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$. See their Figs. 12 and 13 for excluded regions in the parameter space in various 2HDMs.
- 12 AAD 21AF search for production of a heavy H_2^0 state decaying to ZZ in the final states $\ell^+\ell^-\ell'^+\ell'^-$ and $\ell^+\ell^-\nu\bar{\nu}$ in 139 fb^{-1} of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$. See their Figs. 6 and 7 for excluded parameter regions of the 2HDM Type I and II.
- 13 AAD 21AI search for production of an A^0 in gluon-gluon fusion and in association with a $b\bar{b}$, decaying to $ZH_2^0 \rightarrow \ell^+\ell^-b\bar{b}$ or $\ell^+\ell^-W^+W^-$ in 139 fb^{-1} of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$. See their Figs. 10 and 14 for excluded regions in the parameter space of various 2HDMs.
- 14 AAD 20 combine measurements on H^0 production and decay using data taken in years 2015–2017 (up to 79.8 fb^{-1}) of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$. See their Fig. 18 for excluded regions in various 2HDMs.
- 15 AAD 20L search for b -associated production of H_2^0 decaying to $b\bar{b}$ in 27.8 fb^{-1} of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$. See their Figs. 10 and 11 for excluded regions in the flipped two Higgs doublet model.
- 16 SIRUNYAN 20AA search for $H_2^0 \rightarrow ZA^0$, $A^0 \rightarrow b\bar{b}$ or $A^0 \rightarrow ZH_2^0$, $H_2^0 \rightarrow b\bar{b}$ in 35.9 fb^{-1} of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$. See their Figs. 8 and 9 for excluded regions in the parameter space of Type-II two Higgs doublet model.
- 17 SIRUNYAN 20Y search for gluon-fusion and vector-boson-fusion production of H_2^0 decaying to W^+W^- in the final states $\ell\nu\ell\nu$ and $\ell\nu qq$ in 35.9 fb^{-1} of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$. See their Fig. 7 for excluded regions in Type I and II two Higgs doublet models.
- 18 SIRUNYAN 19AE search for a pseudoscalar resonance produced in association with a $b\bar{b}$ pair, decaying to $\tau^+\tau^-$ in 35.9 fb^{-1} of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$. See their Fig. 4 for cross section limits for $m_{A^0} = 25\text{--}70 \text{ GeV}$ and comparison with some representative 2HDMs.

- 19 SIRUNYAN 19AV search for a scalar resonance produced by gluon fusion or b associated production, decaying to $ZH^0 \rightarrow \ell^+ \ell^- b\bar{b}$ ($\ell = e, \mu$) or $\nu\bar{\nu}b\bar{b}$ in 35.9 fb^{-1} of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$. See their Figs. 6 and 7 for excluded regions in the parameter space of various 2HDMs.
- 20 AABOUD 18AH search for production of an A^0 in gluon-gluon fusion and in association with a $b\bar{b}$, decaying to $ZH^0 \rightarrow \ell^+ \ell^- b\bar{b}$ in 36.1 fb^{-1} of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$. See their Fig. 6 for excluded regions in the parameter space of various 2HDMs.
- 21 AABOUD 18AI search for production of an A^0 in gluon-gluon fusion and in association with a $b\bar{b}$, decaying to ZH^0 in the final states $\nu\bar{\nu}b\bar{b}$ and $\ell^+ \ell^- b\bar{b}$ in 36.1 fb^{-1} of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$. See their Figs. 7 and 8 for excluded regions in the parameter space in various 2HDMs.
- 22 AABOUD 18BF search for production of a heavy H_2^0 state decaying to ZZ in the final states $\ell^+ \ell^- \ell^+ \ell^-$ and $\ell^+ \ell^- \nu\bar{\nu}$ in 36.1 fb^{-1} of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$. See their Figs. 8 and 9 for excluded parameter regions in 2HDM Type I and II.
- 23 AABOUD 18CE search for the process $pp \rightarrow H_2^0/A^0 t\bar{t}$ followed by the decay $H_2^0/A^0 \rightarrow t\bar{t}$ in 36.1 fb^{-1} of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$. See their Fig. 12 for limits on cross section times branching ratio, and for lower limits on $\tan\beta$ for $m_{H_2^0}, m_{A^0} = 0.4\text{--}1.0 \text{ TeV}$ in the 2HDM type II.
- 24 HALLER 18 perform global fits in the framework of two-Higgs-doublet models (type I, II, lepton specific, flipped). See their Fig. 8 for allowed parameter regions from fits to LHC H^0 measurements, Fig. 9 bottom and charm decays, Fig. 10 muon anomalous magnetic moment, Fig. 11 electroweak precision data, and Fig. 12 by combination of all data.
- 25 SIRUNYAN 18BP search for production of $H_2^0/A^0 \rightarrow b\bar{b}$ by b -associated production in 35.7 fb^{-1} of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$. See their Fig. 6 for the limits on cross section times branching ratio for $m_{H_2^0}, m_{A^0} = 0.3\text{--}1.3 \text{ TeV}$, and Figs. 8 and 9 for excluded regions in the parameter space of type-II and flipped 2HDMs.
- 26 SIRUNYAN 18ED search for production of an A^0 in gluon-gluon fusion and in association with a $b\bar{b}$, decaying to ZH^0 in the final states $\nu\bar{\nu}b\bar{b}$ or $\ell^+ \ell^- b\bar{b}$ in 35.9 fb^{-1} of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$. See their Fig. 9 for excluded regions in the parameter space in Type I and II 2HDMs.
- 27 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 $E_{\text{cm}} = 8 \text{ TeV}$. See their Fig. 3 and Table III for excluded parameter regions in Type II Two-Higgs-Doublet-Models.
- 28 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 $E_{\text{cm}} = 8 \text{ TeV}$. Limits are set in the range $m_{A^0} = 25\text{--}60 \text{ GeV}$. See their Fig. 5 for upper limits on $\sigma(A^0 b\bar{b}) \cdot \text{B}(A^0 \rightarrow \mu^+ \mu^-)$.
- 29 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 Figs. 13 and 14 for excluded parameter regions in Type I and II models.
- 30 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. 11 for limits on $\tan\beta$ for $m_{A^0} = 230\text{--}350 \text{ GeV}$.
- 31 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 $E_{\text{cm}} = 8 \text{ TeV}$. See their Fig. 3 for upper limits on $\sigma(A^0 b\bar{b}) \cdot \text{B}(A^0 \rightarrow \tau^+ \tau^-)$.
- 32 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 $E_{\text{cm}} = 8 \text{ TeV}$. See their Fig. 4 for cross section limits and Fig. 5 for excluded region in the parameter space.

- 33 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 Figs. 15–18 for excluded regions in the parameter space.
- 34 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.
- 35 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.
- 36 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 $m_{A^0} = 300 \text{ GeV}$.
- 37 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 $m_{H^\pm} = 225\text{--}825 \text{ GeV}$.
- 38 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.
- 39 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.
- 40 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 $H_1^0 \rightarrow A^0 A^0$.
- 41 ABDALLAH 05D search for $e^+e^- \rightarrow H^0 Z$ and $H^0 A^0$ with H^0, A^0 decaying to two jets of any flavor including gg . The limit is for SM $H^0 Z$ production cross section with $\text{B}(H^0 \rightarrow jj) = 1$.
- 42 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.
- 43 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.
- 44 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.
- 45 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 $H_1^0, A^0 \rightarrow q\bar{q}, gg$ are searched for. See their Figs. 15,16 for excluded regions.
- 46 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 $m_H\text{--}m_A$ plane. Updates the results of ACKERSTAFF 98S.
- 47 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.
- 48 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	$H^0 \rightarrow WW^{(*)}$
		2 AALTONEN 13L	CDF	$H^0 \rightarrow \gamma\gamma, WW^*, ZZ^*$
none 100–116	95	3 AALTONEN 13M	TEVA	$H^0 \rightarrow \gamma\gamma, WW^*, ZZ^*$
none 100–113	95	4 ABAZOV 13G	D0	$H^0 \rightarrow WW^{(*)}$
		5 ABAZOV 13H	D0	$H^0 \rightarrow \gamma\gamma$
		6 ABAZOV 13I	D0	$H^0 \rightarrow WW^{(*)}$
none 100–114	95	7 ABAZOV 13J	D0	$H^0 \rightarrow WW^{(*)}, ZZ^{(*)}$
		8 ABAZOV 13L	D0	$H^0 \rightarrow \gamma\gamma, WW^*, ZZ^*$
none 110–147	95	9 CHATRCHYAN 13AL	CMS	$H^0 \rightarrow \gamma\gamma$
none 110–118, 119.5–121	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 12AO 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 AABOUD	19AI ATLS	$W W/Z Z$ fusion
		² AAD	15BD ATLS	$pp \rightarrow H^0 W X, H^0 Z X$
		³ AAD	15BH ATLS	jet + missing E_T
		⁴ AAD	14BA ATLS	secondary vertex
		⁵ AAD	14O ATLS	$pp \rightarrow H^0 Z X$
		⁶ CHATRCHYAN	14B CMS	$pp \rightarrow H^0 Z X, qqH^0 X$
		⁷ AAD	13AG ATLS	secondary vertex
		⁸ AAD	13AT ATLS	electron jets
		⁹ CHATRCHYAN	13BJ CMS	
		¹⁰ AAD	12AQ ATLS	secondary vertex
		¹¹ AALTONEN	12AB CDF	secondary vertex
		¹² AALTONEN	12U CDF	secondary vertex
>108.2	95	¹³ ABBIENDI	10 OPAL	
		¹⁴ ABBIENDI	07 OPAL	large width
>112.3	95	¹⁵ ACHARD	05 L3	
>112.1	95	¹⁵ ABDALLAH	04B DLPH	
>114.1	95	¹⁵ HEISTER	02 ALEP	$E_{\text{cm}} \leq 209$ GeV
>106.4	95	¹⁵ BARATE	01C ALEP	$E_{\text{cm}} \leq 202$ GeV
> 89.2	95	¹⁶ ACCIARRI	00M L3	

¹ **AABOUD 19AI** search for $H_{1,2}^0$ production by vector boson fusion and decay to invisible final states in 36.1 fb^{-1} of pp collisions at $E_{\text{cm}} = 13$ TeV. See their Fig. 6(b) for limits on cross section times branching ratios for $m_{H_{1,2}^0} = 0.1\text{--}3$ TeV.

² **AAD 15BD** search for $pp \rightarrow H^0 W X$ and $pp \rightarrow H^0 Z X$ with W or Z decaying hadronically and H^0 decaying to invisible final states in 20.3 fb^{-1} at $E_{\text{cm}} = 8$ TeV. See their Fig. 6 for a limit on the cross section times branching ratio for $m_{H^0} = 115\text{--}300$ GeV.

³ **AAD 15BH** search for events with a jet and missing E_T in 20.3 fb^{-1} of pp collisions at $E_{\text{cm}} = 8$ TeV. Limits on $\sigma(H^0) B(H^0 \rightarrow \text{invisible}) < (44\text{--}10)$ pb (95%CL) is given for $m_{H^0} = 115\text{--}300$ GeV.

⁴ **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.
- 5 AAD 140 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 $m_{H^0} = 110\text{--}400 \text{ GeV}$.
 - 6 CHATRCHYAN 14B search for $pp \rightarrow H^0 ZX$, $Z \rightarrow \ell\ell$ and $Z \rightarrow b\bar{b}$, and also $pp \rightarrow qqH^0X$ 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 $m_{H^0} = 100\text{--}400 \text{ GeV}$.
 - 7 AAD 13AG search for H^0 production in the decay mode $H^0 \rightarrow X^0X^0$, where X^0 is a long-lived particle which decays to $\mu^+\mu^-X'^0$, in 1.9 fb^{-1} of pp collisions at $E_{\text{cm}} = 7 \text{ TeV}$. See their Fig. 7 for limits on cross section times branching ratio.
 - 8 AAD 13AT search for H^0 production in the decay $H^0 \rightarrow X^0X^0$, where X^0 eventually decays to clusters of collimated e^+e^- pairs, in 2.04 fb^{-1} of pp collisions at $E_{\text{cm}} = 7 \text{ TeV}$. See their Fig. 3 for limits on cross section times branching ratio.
 - 9 CHATRCHYAN 13BJ search for H^0 production in the decay chain $H^0 \rightarrow X^0X^0$, $X^0 \rightarrow \mu^+\mu^-X'^0$ 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.
 - 10 AAD 12AQ search for H^0 production in the decay mode $H^0 \rightarrow X^0X^0$, 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 $E_{\text{cm}} = 7 \text{ TeV}$. See their Fig. 3 for limits on cross section times branching ratio for $m_{H^0} = 120, 140 \text{ GeV}$, $m_{X^0} = 20, 40 \text{ GeV}$ in the $c\tau$ range of $0.5\text{--}35 \text{ m}$.
 - 11 AALTONEN 12AB search for H^0 production in the decay $H^0 \rightarrow X^0X^0$, where X^0 eventually decays to clusters of collimated $\ell^+\ell^-$ pairs, in 5.1 fb^{-1} of $p\bar{p}$ collisions at $E_{\text{cm}} = 1.96 \text{ TeV}$. Cross section limits are provided for a benchmark MSSM model incorporating the parameters given in Table VI.
 - 12 AALTONEN 12U search for H^0 production in the decay mode $H^0 \rightarrow X^0X^0$, where X^0 is a long-lived particle with $c\tau \approx 1 \text{ cm}$ which decays mainly to $b\bar{b}$, in 3.2 fb^{-1} of $p\bar{p}$ collisions at $E_{\text{cm}} = 1.96 \text{ TeV}$. See their Figs. 9 and 10 for limits on cross section times branching ratio for $m_{H^0} = (130\text{--}170) \text{ GeV}$, $m_{X^0} = 20, 40 \text{ GeV}$.
 - 13 ABBIENDI 10 search for $e^+e^- \rightarrow H^0Z$ with H^0 decaying invisibly. The limit assumes SM production cross section and $B(H^0 \rightarrow \text{invisible}) = 1$.
 - 14 ABBIENDI 07 search for $e^+e^- \rightarrow H^0Z$ 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 $\sigma \cdot B(H^0 \rightarrow \text{invisible}) < (0.07\text{--}0.57) \text{ pb}$ (95%CL) is obtained at $E_{\text{cm}} = 206 \text{ GeV}$ for $m_{H^0} = 60\text{--}114 \text{ GeV}$.
 - 15 Search for $e^+e^- \rightarrow H^0Z$ with H^0 decaying invisibly. The limit assumes SM production cross section and $B(H^0 \rightarrow \text{invisible}) = 1$.
 - 16 ACCIARRI 00M search for $e^+e^- \rightarrow ZH^0$ with H^0 decaying invisibly at $E_{\text{cm}} = 183\text{--}189 \text{ GeV}$. 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 $\mathcal{O}(10) \text{ GeV}$.

VALUE (GeV)	DOCUMENT ID	TECN	COMMENT
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●			
1	AAD	25AT ATLS	$H \rightarrow ZA^0$
2	ADACHI	23A BEL2	$\tau \rightarrow eA^0, \tau \rightarrow \mu A^0$
3	TUMASYAN	23AR CMS	$H \rightarrow A^0A^0 \rightarrow 4\gamma$
4	ABLIKIM	22H BES3	$J/\psi \rightarrow A^0\gamma$
5	JIA	22 BELL	$\Upsilon(1S) \rightarrow A^0\gamma$
6	AAD	20AE ATLS	$H^0 \rightarrow ZA^0$

7	AABOUD	18AP ATLS	$H^0 \rightarrow A^0 A^0$
8	KHACHATRY...17AZ	CMS	$H^0 \rightarrow A^0 A^0$
9	ABLIKIM	16E BES3	$J/\psi \rightarrow A^0 \gamma$
10	KHACHATRY...16F	CMS	$H^0 \rightarrow A^0 A^0$
11	LEES	15H BABR	$\Upsilon(1S) \rightarrow A^0 \gamma$
12	LEES	13C BABR	$\Upsilon(1S) \rightarrow A^0 \gamma$
13	LEES	13L BABR	$\Upsilon(1S) \rightarrow A^0 \gamma$
14	LEES	13R BABR	$\Upsilon(1S) \rightarrow A^0 \gamma$
15	ABLIKIM	12 BES3	$J/\psi \rightarrow A^0 \gamma$
16	CHATRCHYAN	12V CMS	$A^0 \rightarrow \mu^+ \mu^-$
17	AALTONEN	11P CDF	$t \rightarrow bH^+, H^+ \rightarrow W^+ A^0$
18,19	ABOUZAID	11A KTEV	$K_L \rightarrow \pi^0 \pi^0 A^0, A^0 \rightarrow \mu^+ \mu^-$
20	DEL-AMO-SA...11J	BABR	$\Upsilon(1S) \rightarrow A^0 \gamma$
21	LEES	11H BABR	$\Upsilon(2S, 3S) \rightarrow A^0 \gamma$
22	ANDREAS	10 RVUE	
19,23	HYUN	10 BELL	$B^0 \rightarrow K^{*0} A^0, A^0 \rightarrow \mu^+ \mu^-$
19,24	HYUN	10 BELL	$B^0 \rightarrow \rho^0 A^0, A^0 \rightarrow \mu^+ \mu^-$
25	AUBERT	09P BABR	$\Upsilon(3S) \rightarrow A^0 \gamma$
26	AUBERT	09Z BABR	$\Upsilon(2S) \rightarrow A^0 \gamma$
27	AUBERT	09Z BABR	$\Upsilon(3S) \rightarrow A^0 \gamma$
19,28	TUNG	09 K391	$K_L \rightarrow \pi^0 \pi^0 A^0, A^0 \rightarrow \gamma \gamma$
29	LOVE	08 CLEO	$\Upsilon(1S) \rightarrow A^0 \gamma$
30	BESSON	07 CLEO	$\Upsilon(1S) \rightarrow \eta_b \gamma$
31	PARK	05 HYCP	$\Sigma^+ \rightarrow p A^0, A^0 \rightarrow \mu^+ \mu^-$
32	BALEST	95 CLE2	$\Upsilon(1S) \rightarrow A^0 \gamma$
33	ANTREASYAN	90c CBAL	$\Upsilon(1S) \rightarrow A^0 \gamma$

¹AAD 25AT search for the decay $H \rightarrow Z A^0$, $Z \rightarrow \ell^+ \ell^-$, A^0 decaying hadronically (gg or $q\bar{q}$), in 140 fb^{-1} of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$. See their Fig. 4 for limits on $B(H \rightarrow Z A^0)$ with assumptions $B(A^0 \rightarrow gg) = 1$ for $m_{A^0} = 0.5\text{--}3.5 \text{ GeV}$, or $B(A^0 \rightarrow q\bar{q}) = 1$ for $m_{A^0} = 1.5\text{--}3.5 \text{ GeV}$. Supersedes AAD 20AE.

²ADACHI 23A search for flavor-changing τ decays $\tau \rightarrow e A^0$ and $\tau \rightarrow \mu A^0$, with A^0 invisible, using 62.8 fb^{-1} of $e^+ e^-$ collisions at $E_{\text{cm}} = 10.58 \text{ GeV}$. Limits on $B(\tau \rightarrow e A^0)/B(\tau \rightarrow e \nu \nu)$ in the range $1.1 \times 10^{-3}\text{--}9.7 \times 10^{-3}$ (95% CL) and $B(\tau \rightarrow \mu A^0)/B(\tau \rightarrow \mu \nu \nu)$ in the range $0.7 \times 10^{-3}\text{--}12.2 \times 10^{-3}$ (95% CL) are given for $m_{A^0} = 0\text{--}1.6 \text{ GeV}$. See their Fig. 2.

³TUMASYAN 23AR search for the decay $H \rightarrow A^0 A^0$ with $A^0 \rightarrow \gamma \gamma$ (detected as a merged photonlike object) using 136 fb^{-1} of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$. Limits on $B(H \rightarrow A^0 A^0) \cdot B^2(A^0 \rightarrow \gamma \gamma)$ in the range $0.9 \times 10^{-3}\text{--}3.3 \times 10^{-3}$ (95% CL) are given for $m_{A^0} = 0.1\text{--}1.2 \text{ GeV}$. See their Fig. 2.

⁴ABLIKIM 22H search for the process $J/\psi \rightarrow A^0 \gamma$ with A^0 decaying to $\mu^+ \mu^-$ in 9×10^9 J/ψ events and give limits on $B(J/\psi \rightarrow A^0 \gamma) \cdot B(A^0 \rightarrow \mu^+ \mu^-)$ in the range $1.2 \times 10^{-9}\text{--}7.78 \times 10^{-7}$ (90% CL) for $0.212 \text{ GeV} \leq m_{A^0} \leq 3.0 \text{ GeV}$. See their Fig. 4.

⁵JIA 22 search for the process $\Upsilon(2S) \rightarrow \Upsilon(1S) \pi^+ \pi^- \rightarrow A^0 \gamma \pi^+ \pi^-$ with A^0 decaying to $\tau^+ \tau^-$ or $\mu^+ \mu^-$ in 158×10^6 $\Upsilon(2S)$ events and give limits on $B(\Upsilon(1S) \rightarrow A^0 \gamma) \cdot B(A^0 \rightarrow \tau^+ \tau^-)$ in the range $3.8 \times 10^{-6}\text{--}1.5 \times 10^{-4}$ (90% CL) for $m_{A^0} = 3.6\text{--}9.2 \text{ GeV}$, and $B(\Upsilon(1S) \rightarrow A^0 \gamma) \cdot B(A^0 \rightarrow \mu^+ \mu^-)$ in the range $3.1 \times 10^{-7}\text{--}1.6 \times 10^{-5}$ (90% CL) for $m_{A^0} = 0.21\text{--}9.2 \text{ GeV}$. See their Fig. 4.

- ⁶ AAD 20AE search for the decay $H^0 \rightarrow ZA^0$, $Z \rightarrow \ell^+\ell^-$, A^0 decaying hadronically ($A^0 \rightarrow gg$ or $s\bar{s}$), in 139 fb^{-1} of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$. Limit on the product of production cross section and the $H^0 \rightarrow ZA^0$ branching ratio in the range 17–340 pb (95% CL) is given for $m_{A^0} = 0.5\text{--}4.0 \text{ GeV}$, see their Table I.
- ⁷ AABOUD 18AP search for the decay $H^0 \rightarrow A^0A^0 \rightarrow \mu^+\mu^-\mu^+\mu^-$ in 36.1 fb^{-1} of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$. See their Fig. 10(b) for limits on $B(H^0 \rightarrow A^0A^0)$ in the range $m_{A^0} = 1\text{--}2.5, 4.5\text{--}8 \text{ GeV}$, assuming a type-II two-doublet plus singlet model with $\tan(\beta) = 5$.
- ⁸ KHACHATRYAN 17AZ search for the decay $H^0 \rightarrow A^0A^0 \rightarrow \tau^+\tau^-\tau^+\tau^-$, $\mu^+\mu^-b\bar{b}$, 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.
- ⁹ 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.
- ¹⁰ KHACHATRYAN 16F search for the decay $H^0 \rightarrow A^0A^0 \rightarrow \tau^+\tau^-\tau^+\tau^-$ in 19.7 fb^{-1} of pp collisions at $E_{\text{cm}} = 8 \text{ TeV}$. See their Fig. 8 for cross section limits for $m_{A^0} = 4\text{--}8 \text{ GeV}$.
- ¹¹ 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.
- ¹² 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.
- ¹³ LEES 13L search for the process $\Upsilon(2S) \rightarrow \Upsilon(1S)\pi^+\pi^- \rightarrow A^0\gamma\pi^+\pi^-$ with A^0 decaying to gg or $s\bar{s}$ and give limits on $B(\Upsilon(1S) \rightarrow A^0\gamma) \cdot B(A^0 \rightarrow gg)$ 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.
- ¹⁴ 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.
- ¹⁵ 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.
- ¹⁶ 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.
- ¹⁷ 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 $90 < m_{H^+} < 160 \text{ GeV}$.
- ¹⁸ ABOUZAID 11A search for the decay chain $K_L \rightarrow \pi^0\pi^0A^0$, $A^0 \rightarrow \mu^+\mu^-$ and give a limit $B(K_L \rightarrow \pi^0\pi^0A^0) \cdot B(A^0 \rightarrow \mu^+\mu^-) < 1.0 \times 10^{-10}$ at 90% CL for $m_{A^0} = 214.3 \text{ MeV}$.

- 19 The search was motivated by PARK 05.
- 20 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 $0 \leq m_{A^0} \leq 8.0$ GeV, and $(2.7\text{--}37) \times 10^{-6}$ for $8.0 \leq m_{A^0} \leq 9.2$ GeV.
- 21 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 $0.3 < m_{A^0} < 7$ 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.
- 22 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.
- 23 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 $m_{A^0} = 212\text{--}300$ MeV. The limit for $m_{A^0} = 214.3$ MeV is 2.26×10^{-8} .
- 24 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 $m_{A^0} = 212\text{--}300$ MeV. The limit for $m_{A^0} = 214.3$ MeV is 1.73×10^{-8} .
- 25 AUBERT 09P search for the process $\Upsilon(3S) \rightarrow A^0\gamma$ with $A^0 \rightarrow \tau^+\tau^-$ for $4.03 < m_{A^0} < 9.52$ and $9.61 < m_{A^0} < 10.10$ GeV, and give limits on $B(\Upsilon(3S) \rightarrow A^0\gamma) \cdot B(A^0 \rightarrow \tau^+\tau^-)$ in the range $(1.5\text{--}16) \times 10^{-5}$ (90% CL).
- 26 AUBERT 09Z search for the process $\Upsilon(2S) \rightarrow A^0\gamma$ with $A^0 \rightarrow \mu^+\mu^-$ for $0.212 < m_{A^0} < 9.3$ GeV and give limits on $B(\Upsilon(2S) \rightarrow A^0\gamma) \cdot B(A^0 \rightarrow \mu^+\mu^-)$ in the range $(0.3\text{--}8) \times 10^{-6}$ (90% CL).
- 27 AUBERT 09Z search for the process $\Upsilon(3S) \rightarrow A^0\gamma$ with $A^0 \rightarrow \mu^+\mu^-$ for $0.212 < m_{A^0} < 9.3$ GeV and give limits on $B(\Upsilon(3S) \rightarrow A^0\gamma) \cdot B(A^0 \rightarrow \mu^+\mu^-)$ in the range $(0.3\text{--}5) \times 10^{-6}$ (90% CL).
- 28 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 $m_{A^0} = 194.3\text{--}219.3$ MeV. The limit for $m_{A^0} = 214.3$ MeV is 2.4×10^{-7} .
- 29 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.
- 30 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.
- 31 PARK 05 found three candidate events for $\Sigma^+ \rightarrow p\mu^+\mu^-$ in the HyperCP experiment. Due to a narrow spread in dimuon mass, they hypothesize the events as a possible signal of a new boson. It can be interpreted as a neutral particle with $m_{A^0} = 214.3 \pm 0.5$ MeV and the branching fraction $B(\Sigma^+ \rightarrow pA^0) \cdot B(A^0 \rightarrow \mu^+\mu^-) = (3.1^{+2.4}_{-1.9} \pm 1.5) \times 10^{-8}$.
- 32 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.
- 33 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 is reserved for the 125 GeV particle.

<u>VALUE (GeV)</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●				
1	AAD	25AL ATLS		$t\bar{t}H_2^0/A^0$
2	AAD	25AN ATLS		$t\bar{t}A^0, A^0 \rightarrow b\bar{b}$
3	AAD	25AU ATLS		$H \rightarrow A^0 A^0$
4	AAD	25AW ATLS		$H \rightarrow A^0 A^0$
5	AAD	25AW ATLS		$H \rightarrow A_1^0 A_2^0$
6	AAD	25AY ATLS		$H \rightarrow H_1^0 H_1^0$
7	AAD	25F ATLS		$H_{1/2}^0 \rightarrow Z' Z', Z' \rightarrow \ell^+ \ell^-$
8	AAD	25J ATLS		$H_3^0 \rightarrow H_2^0 H, H_2^0 \rightarrow HH$
9	AAD	25O ATLS		$H_1^0 \rightarrow \gamma\gamma$
10	AAD	25X ATLS		$H \rightarrow A^0 A^0$
11	ADAN	25		$H \rightarrow A^0 A^0$
12	CHEKHOVSKY25C	CMS		$H_2^0/A^0 \rightarrow b\bar{b}$
13	CHEKHOVSKY25D	CMS		$H_{1/2}^0/A^0 \rightarrow \text{invisible}$
14	CHEKHOVSKY25I	CMS		$A^0 \rightarrow ZH$
15	CHEKHOVSKY25J	CMS		$A_2^0 \rightarrow HA_1^0$
16	CORTINA-GIL 25B	NA62		$K^+ \rightarrow \pi^+ H_1^0$
17	HAYRAPETY...25A	CMS		$H_1^0 \rightarrow \gamma\gamma$
18	HAYRAPETY...25AP	CMS		$H_3^0 \rightarrow HH_{1/2}^0$
19	HAYRAPETY...25C	CMS		$H_3^0 \rightarrow H_1^0 H_1^0$
20	HAYRAPETY...25I	CMS		$A^0 \rightarrow ZH_2^0, H_2^0 \rightarrow t\bar{t}$
21	HAYRAPETY...25P	CMS		$b\bar{b}A^0, A^0 \rightarrow \text{invisible}$
22	AAD	24A ATLS		$H_2^0 \rightarrow Z\gamma$
23	AAD	24AP ATLS		$H_2^0, A^0 \rightarrow t\bar{t}$
24	AAD	24BQ ATLS		$H \rightarrow A^0 A^0$
25	AAD	24BV ATLS		$H_2^0 \rightarrow HH$
26	AAD	24BW ATLS		$H_3^0 \rightarrow H_2^0 H$
27	AAD	24BX ATLS		$H_4^0 \rightarrow H_2^0 H_3^0$
28	AAD	24BX ATLS		$A^0 \rightarrow H_2^0 Z$
29	AAD	24CA ATLS		$H_3^0 \rightarrow H_{1,2}^0 H$
30	AAD	24CD ATLS		$H_2^0 \rightarrow ZA$
31	AAD	24CF ATLS		$A^0 \rightarrow \tau^+ \tau^-$
32	AAD	24CI ATLS		$H_2^0, A^0 \rightarrow \text{invisible}$
33	AAD	24CK ATLS		two doublet + pseudoscalar + Dirac DM
34	AAD	24H ATLS		$H_2^0 \rightarrow HH$
35	AAD	24K ATLS		$H \rightarrow ZA^0$
36	ADACHI	24F BEL2		$H_1^0 \rightarrow \mu^+ \mu^-$
37	HAYRAPETY...24AA	CMS		$H \rightarrow A^0 A^0$
38	HAYRAPETY...24AE	CMS		$H_2^0 \rightarrow HH$

39	HAYRAPETY...24AF	CMS	$H \rightarrow A^0 A^0$
40	HAYRAPETY...24AI	CMS	$H \rightarrow H_1^0 H_1^0$, long-lived
41	HAYRAPETY...24AJ	CMS	$H_2^0 \rightarrow \gamma\gamma$
42	HAYRAPETY...24AZ	CMS	$A^0 A^0, A^0 \rightarrow \mu^+ \mu^-$
43	HAYRAPETY...24AZ	CMS	$H, H_{1,2}^0 \rightarrow A^0 A^0, A^0 \rightarrow \mu^+ \mu^-$
44	HAYRAPETY...24I	CMS	$H \rightarrow Z A^0$
45	TUMASYAN 24A	CMS	$H_{1,2}^0 \rightarrow e^+ e^-, \mu^+ \mu^-, \tau^+ \tau^-$
46	TUMASYAN 24B	CMS	$H_2^0 \rightarrow H H$
47	TUMASYAN 24B	CMS	$H_3^0 \rightarrow H_{1,2}^0 H$
48	AAD	23AD ATLS	$H_2^0 \rightarrow H H$
49	AAD	23AD ATLS	$A^0 \rightarrow Z H_2^0 \rightarrow Z H H$
50	AAD	23AJ ATLS	$H^\pm \rightarrow W^\pm A^0$
51	AAD	23BD ATLS	$t \rightarrow q H_{1,2}^0$
52	AAD	23BE ATLS	$H_2^0 \rightarrow W^+ W^-$
53	AAD	23BG ATLS	$t \bar{t} H_2^0 / A^0$
54	AAD	23BW ATLS	$A^0 t \bar{t}, A^0 \rightarrow \mu^+ \mu^-$
55	AAD	23BX ATLS	$H + \text{invisible } A^0$
56	AAD	23CA ATLS	$H_3^0 \rightarrow H_2^0 H$
57	AAD	23CR ATLS	flavor changing H_2^0
58	AAD	23O ATLS	$A^0 \rightarrow Z H$
59	AAD	23R ATLS	$A^0 \rightarrow \gamma\gamma$
60	AAD	23U ATLS	$H_2^0 \rightarrow Z \gamma$
61	AAD	23Z ATLS	$H_2^0 \rightarrow H H$
62	HAYRAPETY...23C	CMS	$H_{1,2}^0 \rightarrow e \mu$
63	HAYRAPETY...23G	CMS	$A^0 \rightarrow \mu^+ \mu^-$
64	TUMASYAN 23	CMS	$H_3^0 \rightarrow H_{1,2}^0 H$
65	TUMASYAN 23M	CMS	$H \rightarrow A^0 A^0$
66	TUMASYAN 23O	CMS	$H_2^0 \rightarrow H H$
67	TUMASYAN 23S	CMS	$H_{1,2}^0 \rightarrow \tau^+ \tau^-$
68	AAD	22A ATLS	$H \rightarrow A^0 A^0$
69	AAD	22D ATLS	$Z A^0, A^0 \rightarrow \text{invisible}$
70	AAD	22F ATLS	$H_2^0 \rightarrow H H$
71	AAD	22I ATLS	$H \rightarrow \tilde{\chi}_2^0 \tilde{\chi}_1^0, \tilde{\chi}_2^0 \rightarrow A^0 \tilde{\chi}_1^0, A^0 \rightarrow b \bar{b}$
72	AAD	22J ATLS	$H \rightarrow Z A^0$
73	AAD	22J ATLS	$H \rightarrow A^0 A^0, H_1^0 H_1^0$
74	AAD	22P ATLS	$H_1^0, H_2^0 \rightarrow \text{invisible}$
75	AAD	22Y ATLS	$H_2^0 \rightarrow H H$
76	ABRATENKO 22A	MCBN	$K^+ \rightarrow H_1^0 \pi^+$
77	TUMASYAN 22AK	CMS	$H_3^0 \rightarrow H_1^0 H_1^0$
78	TUMASYAN 22D	CMS	$H_2^0 \rightarrow W^+ W^-$
79	AAD	21AF ATLS	$H_2^0 \rightarrow Z Z$

80	AAD	21AI ATLS	$A^0 \rightarrow ZH_2^0$
81	AAD	21AY ATLS	$H_2^0 \rightarrow \gamma\gamma$
82	AAD	21AZ ATLS	$A_2^0 \rightarrow HA_1^0$
83	AAD	21BB ATLS	$A_2^0 \rightarrow HA_1^0$
84	AAD	21BE ATLS	$A_1^0 \rightarrow \text{invisible}$
85	ABRATENKO	21 MCBN	$K^+ \rightarrow H_1^0\pi^+$
86	SIRUNYAN	21A CMS	$H_2^0 \rightarrow ZA^0, A^0 \rightarrow \text{invisible}$
87	TUMASYAN	21F CMS	$H_3^0 \rightarrow HH_{1,2}^0$
88	AAD	20AA ATLS	$H_2^0/A^0 \rightarrow \tau^+\tau^-$
89	AAD	20AI ATLS	$H \rightarrow A^0A^0$
90	AAD	20AO ATLS	$H_2^0 \rightarrow HH$
91	AAD	20C ATLS	$H_2^0 \rightarrow HH$
92	AAD	20L ATLS	$H_2^0 \rightarrow b\bar{b}$
93	AAD	20X ATLS	$H_2^0 \rightarrow HH$
94	AAIJ	20AL LHCb	$A^0 \rightarrow \mu^+\mu^-$
95	SIRUNYAN	20 CMS	$H \rightarrow A^0A^0$
96	SIRUNYAN	20AA CMS	$H_2^0 \rightarrow ZA^0$ or $A^0 \rightarrow ZH_2^0$
97	SIRUNYAN	20AC CMS	$A^0 \rightarrow ZH$
98	SIRUNYAN	20AD CMS	$H_2^0 \rightarrow \mu\tau, e\tau$
99	SIRUNYAN	20AF CMS	$H_2^0/A^0 \rightarrow t\bar{t}$
100	SIRUNYAN	20AP CMS	$H, H_2^0 \rightarrow A^0A^0$
101	SIRUNYAN	20Y CMS	$H_2^0 \rightarrow W^+W^-$
102	SIRUNYAN	20Z CMS	$t\bar{t}H_{1,2}^0$ or $t\bar{t}A^0, H_{1,2}^0/A^0 \rightarrow e^+e^-, \mu^+\mu^-$
103	AABOUD	19A ATLS	$H_2^0 \rightarrow HH$
104	AABOUD	19AG ATLS	$H \rightarrow A^0A^0$
105	AABOUD	19O ATLS	$H_2^0 \rightarrow HH$
106	AABOUD	19T ATLS	$H_2^0 \rightarrow HH$
107	AABOUD	19V ATLS	two doublet + pseudoscalar model
108	AABOUD	19Y ATLS	$H_2^0 \rightarrow \mu^+\mu^-$
109	AALTONEN	19 CDF	$H_{1,2}^0 \rightarrow b\bar{b}$
110	SIRUNYAN	19 CMS	$H_2^0 \rightarrow HH$
111	SIRUNYAN	19AE CMS	$A^0 \rightarrow \tau^+\tau^-$
112	SIRUNYAN	19AN CMS	$A_2^0 \rightarrow HA_1^0$
113	SIRUNYAN	19AV CMS	$A^0 \rightarrow ZH$
114	SIRUNYAN	19B CMS	$H_{1,2}^0/A^0 \rightarrow b\bar{b}$
115	SIRUNYAN	19BB CMS	$H_1^0 \rightarrow \gamma\gamma$
116	SIRUNYAN	19BD CMS	$H \rightarrow A^0A^0$
117	SIRUNYAN	19BE CMS	$H_2^0 \rightarrow HH$
118	SIRUNYAN	19BQ CMS	$H_{1,2}^0 \rightarrow A^0A^0$
119	SIRUNYAN	19CR CMS	$H_2^0/A^0 \rightarrow \mu^+\mu^-$
120	SIRUNYAN	19H CMS	$H_2^0 \rightarrow HH$
121	AABOUD	18AA ATLS	$H_2^0 \rightarrow Z\gamma$

122	AABOUD	18AG ATLS	$H \rightarrow A^0 A^0$
123	AABOUD	18AH ATLS	$A^0 \rightarrow Z H_2^0$
124	AABOUD	18AI ATLS	$A^0 \rightarrow Z H$
125	AABOUD	18BF ATLS	$H_2^0 \rightarrow Z Z$
126	AABOUD	18BU ATLS	$H_2^0 \rightarrow H H$
127	AABOUD	18BX ATLS	$H \rightarrow A^0 A^0$
128	AABOUD	18CQ ATLS	$H_2^0 \rightarrow H H$
129	AABOUD	18F ATLS	$H_2^0 \rightarrow W^+ W^-, Z Z$
130	AAIJ	18AMLHCB	$H_{1,2}^0 \rightarrow \mu \tau$
131	AAIJ	18AQ LHCB	$A^0 \rightarrow \mu^+ \mu^-$
132	AAIJ	18AQ LHCB	$H \rightarrow A^0 A^0, A^0 \rightarrow \mu^+ \mu^-$
133	SIRUNYAN	18AF CMS	$H_2^0 \rightarrow H H$
134	SIRUNYAN	18BA CMS	$H_2^0 \rightarrow Z Z$
135	SIRUNYAN	18CW CMS	$H_2^0 \rightarrow H H$
136	SIRUNYAN	18DK CMS	$H_2^0 \rightarrow Z \gamma$
137	SIRUNYAN	18DT CMS	$H \rightarrow A^0 A^0$
138	SIRUNYAN	18DU CMS	$H_2^0 \rightarrow \gamma \gamma$
139	SIRUNYAN	18ED CMS	$A^0 \rightarrow Z H$
140	SIRUNYAN	18EE CMS	$H \rightarrow A^0 A^0$
141	SIRUNYAN	18F CMS	$pp, 13 \text{ TeV}, H_2^0 \rightarrow H H$
142	AABOUD	17 ATLS	$H_2^0 \rightarrow Z \gamma$
143	AABOUD	17AP ATLS	$H_2^0 \rightarrow \gamma \gamma$
144	AABOUD	17AW ATLS	$H_2^0 \rightarrow Z \gamma$
145	KHACHATRY...17AZ	CMS	$H \rightarrow A^0 A^0$
146	KHACHATRY...17D	CMS	$pp, 8, 13 \text{ TeV}, H_2^0 \rightarrow Z \gamma$
147	KHACHATRY...17R	CMS	$H_2^0 \rightarrow \gamma \gamma$
148	SIRUNYAN	17CN CMS	$pp, 8 \text{ TeV}, H_2^0 \rightarrow H H$
149	SIRUNYAN	17Y CMS	$pp, 8, 13 \text{ TeV}, H_2^0 \rightarrow Z \gamma$
150	AABOUD	16AB ATLS	$H \rightarrow A^0 A^0$
151	AABOUD	16AE ATLS	$H_2^0 \rightarrow W^+ W^-, Z Z$
152	AABOUD	16H ATLS	$H_2^0 \rightarrow \gamma \gamma$
153	AABOUD	16I ATLS	$H_2^0 \rightarrow H H$
154	AAD	16AX ATLS	$H \rightarrow Z Z$
155	AAD	16C ATLS	$H \rightarrow W^+ W^-$
156	AAD	16L ATLS	$H \rightarrow A^0 A^0$
157	AAD	16L ATLS	$H_2^0 \rightarrow A^0 A^0$
158	AALTONEN	16C CDF	$H_1^0 H^\pm \rightarrow H_1^0 H_1^0 W^*,$ $H_1^0 \rightarrow \gamma \gamma$
159	KHACHATRY...16BG	CMS	$H_2^0 \rightarrow H H$
160	KHACHATRY...16BQ	CMS	$pp, 8 \text{ TeV}, H_2^0 \rightarrow H H$
161	KHACHATRY...16F	CMS	$H \rightarrow H_1 H_1$
162	KHACHATRY...16M	CMS	$H_2^0 \rightarrow \gamma \gamma$
163	KHACHATRY...16P	CMS	$H_2^0 \rightarrow H H$
164	KHACHATRY...16P	CMS	$A^0 \rightarrow Z H$
165	AAD	15BK ATLS	$H_2^0 \rightarrow H H$

	166	AAD	15BZ	ATLS	$H \rightarrow A^0 A^0$	
	167	AAD	15BZ	ATLS	$H_2^0 \rightarrow A^0 A^0$	
	168	AAD	15CE	ATLS	$H_2^0 \rightarrow HH$	
	169	AAD	15H	ATLS	$H_2^0 \rightarrow HH$	
	170	AAD	15S	ATLS	$A^0 \rightarrow ZH$	
	171	KHACHATRY...	15AW	CMS	$H_2^0 \rightarrow W^+ W^-, ZZ$	
	172	KHACHATRY...	15BB	CMS	$H \rightarrow \gamma\gamma$	
	173	KHACHATRY...	15N	CMS	$A^0 \rightarrow ZH$	
	174	KHACHATRY...	15O	CMS	$A^0 \rightarrow ZH$	
	175	KHACHATRY...	15R	CMS	$H_2^0 \rightarrow HH$	
	176	AAD	14AP	ATLS	$H \rightarrow \gamma\gamma$	
	177	AAD	14M	ATLS	$H_2^0 \rightarrow H^\pm W^\mp \rightarrow$ $HW^\pm W^\mp, H \rightarrow b\bar{b}$	
	178	CHATRCHYAN	14G	CMS	$H \rightarrow WW^{(*)}$	
	179	KHACHATRY...	14P	CMS	$H \rightarrow \gamma\gamma$	
	180	AALTONEN	13P	CDF	$H^{i0} \rightarrow H^\pm W^\mp \rightarrow$ HW^+W^-	
	181	CHATRCHYAN	13BJ	CMS	$H \rightarrow A^0 A^0$	
	182	AALTONEN	11P	CDF	$t \rightarrow bH^+, H^+ \rightarrow W^+ A^0$	
	183	ABBIENDI	10	OPAL	$H \rightarrow \tilde{\chi}_1^0 \tilde{\chi}_2^0$	
	184	SCHAEL	10	ALEP	$H \rightarrow A^0 A^0$	
	185	ABAZOV	09V	D0	$H \rightarrow A^0 A^0$	
none 3–63	95	186	ABBIENDI	05A	OPAL	A^0 , Type II model
>104	95	187	ABBIENDI	04K	OPAL	$H \rightarrow 2$ jets
		188	ABDALLAH	04	DLPH	HVV couplings
>110.3	95	189	ACHARD	04B	L3	$H \rightarrow 2$ jets
		190	ACHARD	04F	L3	Anomalous coupling
		191	ABBIENDI	03F	OPAL	$e^+e^- \rightarrow HZ, H \rightarrow$ any
		192	ABBIENDI	03G	OPAL	$H_1^0 \rightarrow A^0 A^0$
>105.4	95	193,194	HEISTER	02L	ALEP	$H_1^0 \rightarrow \gamma\gamma$
>109.1	95	195	HEISTER	02M	ALEP	$H \rightarrow 2$ jets or $\tau^+ \tau^-$
none 12–56	95	196	ABBIENDI	01E	OPAL	A^0 , Type-II model
		197	ACCIARRI	00R	L3	$e^+e^- \rightarrow H\gamma$ and/or $H \rightarrow$ $\gamma\gamma$
		198	ACCIARRI	00R	L3	$e^+e^- \rightarrow e^+e^- H$
		199	GONZALEZ...	98B	RVUE	Anomalous coupling
		200	KRAWCZYK	97	RVUE	$(g-2)_\mu$
		201	ALEXANDER	96H	OPAL	$Z \rightarrow H\gamma$

¹ AAD 25AL search for production of H_2^0/A^0 in association with a $t\bar{t}$ pair, decaying to $t\bar{t}$, resulting in final states with one lepton or two opposite-sign leptons, using 139 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 $m_{H_2^0}$ and/or $m_{A^0} = 0.4\text{--}1.0 \text{ TeV}$. Combined limits with AAD 23BG are shown in Fig. 10.

² AAD 25AN search for production of A^0 in association with a $t\bar{t}$ pair, in the decay $A^0 \rightarrow b\bar{b}$ using 140 fb^{-1} of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$. See their Fig. 9 for limits on cross section times branching ratio for $m_{A^0} = 12\text{--}100 \text{ GeV}$. If the top Yukawa coupling is as strong as the one of the Standard Model Higgs and $B(A^0 \rightarrow b\bar{b}) = 1$, the whole mass range is excluded at 95%CL.

- ³ AAD 25AU search for the decay $H \rightarrow A^0 A^0 \rightarrow \tau^+ \tau^- \tau^+ \tau^-$, each tau pair decaying to hadrons + muon final states, in 140 fb^{-1} of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$. See their Fig. 4 for limits on the product of production cross section (normalized to the SM) and branching ratios in the range $m_{A^0} = 4\text{--}15 \text{ GeV}$, and Fig. 5 for the interpretation in terms of a model with two Higgs doublets plus a singlet.
- ⁴ AAD 25AW search for the decay $H \rightarrow A^0 A^0 \rightarrow b\bar{b}b\bar{b}$ in associated ZH production using 140 fb^{-1} of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$. See their Fig. 14 for limits on the product of production cross section (normalized to the SM) and branching ratios in the range $m_{A^0} = 12\text{--}60 \text{ GeV}$.
- ⁵ AAD 25AW search for the decay $H \rightarrow A_1^0 A_2^0 \rightarrow b\bar{b}b\bar{b}$ and $H \rightarrow A_1^0 A_2^0 \rightarrow A_1^0 A_1^0 A_1^0 \rightarrow b\bar{b}b\bar{b}b\bar{b}$ in associated ZH production using 140 fb^{-1} of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$. See their Fig. 15 for limits on the product of production cross section (normalized to the SM) and branching ratios for several combinations of $m_{A_1^0}$ and $m_{A_2^0}$.
- ⁶ AAD 25AY search for $H \rightarrow H_1^0 H_1^0$ with hadronically decaying H_1^0 having a long lifetime resulting in displaced vertex, using 140 fb^{-1} of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$. The case the parent particle has a different mass ($H_{2/3}^0 \rightarrow H_1^0 H_1^0$) are also examined. See their Figs. 12 and 13 for limits with decay length in the range $0.01\text{--}1000 \text{ m}$.
- ⁷ AAD 25F search for $H_{1/2}^0 \rightarrow Z' Z'$ with $Z' \rightarrow \ell^+ \ell^-$ using 139 fb^{-1} of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$. See their Fig. 5 for limits on production cross section times branching ratios for $m_{H_1^0} = 40\text{--}115 \text{ GeV}$, $m_{H_2^0} = 130\text{--}800 \text{ GeV}$, and $m_{Z'} = 15\text{--}300 \text{ GeV}$.
- ⁸ AAD 25J search for production of H_3^0 decaying to $H_2^0 H$, $H_2^0 \rightarrow HH$ in the $b\bar{b}b\bar{b}b\bar{b}$ final state, using 126 fb^{-1} of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$. See their Figs. 7 and 8 for limits on production cross section times branching ratios in the ranges $m_{H_3^0} = 325\text{--}1500 \text{ GeV}$ and $m_{H_2^0} = 250\text{--}1000 \text{ GeV}$.
- ⁹ AAD 25O search for $H_1^0 \rightarrow \gamma\gamma$ in 140 fb^{-1} of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$. See their Figs. 6(b), 8(b) and 9(b) for limits on cross section times branching ratio for $m_{H_1^0} = 66\text{--}110 \text{ GeV}$. Fig. 9(b) assumes Standard Model Higgs-like properties.
- ¹⁰ AAD 25X search for the decay chain $H \rightarrow A^0 A^0 \rightarrow \gamma\gamma\tau^+\tau^-$ in 140 fb^{-1} of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$. See their Fig. 5(b) for limits on the product of branching ratios for $m_{A^0} = 10\text{--}60 \text{ GeV}$, assuming SM-like production.
- ¹¹ ADAN 25 searches for $H \rightarrow A^0 A^0 \rightarrow \mu^+ \mu^- c\bar{c}$ using publicly available CMS data of 16.4 fb^{-1} of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$. See his Fig. 7 for limits on the product of production cross section (normalized to the SM) and branching ratios in the range $m_{A^0} = 4\text{--}11 \text{ GeV}$, and Fig. 8 for the interpretation in terms of a model with two Higgs doublets plus a singlet.
- ¹² CHEKHOVSKY 25C search for $H_2^0/A^0 \rightarrow b\bar{b}$ by b -associated production using $36.7\text{--}126.9 \text{ fb}^{-1}$ of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$. See their Figs. 11–14 for limits on cross section times branching ratio for $m_{H_2^0}, m_{A^0} = 0.125\text{--}1.8 \text{ TeV}$.
- ¹³ CHEKHOVSKY 25D search for invisibly decaying $H_1^0/H_2^0/A^0$ produced in association with t or $t\bar{t}$, using 138 fb^{-1} of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$. See their Fig. 5 for limits on cross section times branching ratio for masses between 50 and 500 GeV .
- ¹⁴ CHEKHOVSKY 25I search for production of an A^0 in gluon-gluon fusion and in association with a $b\bar{b}$, decaying to ZH in the final states $\ell^+ \ell^- \tau^+ \tau^-$, assuming $B(H \rightarrow \tau^+ \tau^-)$ of the SM, using 138 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 $m_{A^0} = 0.225\text{--}1.0 \text{ TeV}$ for the two production mechanisms, and Figs. 5, 6 for constraints on the combination of the two production mechanisms.

- 15 CHEKHOVSKY 25J search for $A_2^0 \rightarrow HA_1^0$, A_1^0 escaping detection, using 101 fb^{-1} of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$. In the framework of two Higgs doublet plus a singlet model, limits on signal strengths are given in their Figs. 3 and 4 with varying model parameters.
- 16 CORTINA-GIL 25B search for the decay $K^+ \rightarrow \pi^+ H_1^0$, with H_1^0 escaping detection or decaying to $\mu^+ \mu^-$. See their Figs. 2, 3, and 6 for limits on the product of branching ratios for $m_{H_1^0} = 0\text{--}0.33 \text{ GeV}$, and Fig. 9 for limits on the mixing with the Standard Model Higgs boson.
- 17 HAYRAPETYAN 25A search for the decay $H_1^0 \rightarrow \gamma\gamma$ in 132 fb^{-1} of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$. See their Fig. 5 for limits on cross section times branching ratio for $m_{H_1^0} = 70\text{--}110 \text{ GeV}$.
- 18 HAYRAPETYAN 25AP search for $H_3^0 \rightarrow HH_{1/2}^0$ with decays $H \rightarrow b\bar{b}$ and $H_{1/2}^0 \rightarrow \gamma\gamma$ using 132 fb^{-1} of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$. See their Figs. 5 and 6 for limits on cross section times branching ratio for $m_{H_3^0} = 0.24\text{--}1.0 \text{ TeV}$ and $m_{H_{1/2}^0} = 0.07\text{--}0.8 \text{ TeV}$.
- 19 HAYRAPETYAN 25C search for production of H_3^0 in the decay chain $H_3^0 \rightarrow H_1^0 H_1^0$, $H_1^0 \rightarrow \gamma\gamma$ using 138 fb^{-1} of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$. See their Fig. 3 for limits on cross section times branching ratio for $m_{H_3^0} = 0.3\text{--}3 \text{ TeV}$, $m_{H_1^0}/m_{H_3^0} = 0.005\text{--}0.025$.
- 20 HAYRAPETYAN 25I search for $A^0 \rightarrow ZH_2^0$ with $H_2^0 \rightarrow t\bar{t}$ using 138 fb^{-1} of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$. See their Fig. 5 for limits on production cross section times branching ratios for $m_{A^0} = 0.45\text{--}2.1 \text{ TeV}$ and $m_{H_2^0} = 0.35\text{--}2.0 \text{ TeV}$.
- 21 HAYRAPETYAN 25P search for A^0 decaying to invisible final states, produced in association with a $b\bar{b}$ pair, using 138 fb^{-1} of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$. See their Fig. 7 for limits on cross section times branching ratio for $m_{A^0} = 50\text{--}500 \text{ GeV}$ and Fig. 8 for excluded parameter space, both in the two-Higgs-doublet plus singlet pseudoscalar model.
- 22 AAD 24A search for the decay $H_2^0 \rightarrow Z\gamma$ with Z decaying to e^+e^- or $\mu^+\mu^-$ using 140 fb^{-1} of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$. See their Fig. 4 for limits on production cross section times branching ratios for $m_{H_2^0} = 0.22\text{--}3.4 \text{ TeV}$.
- 23 AAD 24AP search for production of a heavy H_2^0 or A^0 decaying to $t\bar{t}$ in 140 fb^{-1} of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$. See their Figs. 15 and 16 for limits on the Yukawa coupling for m_{A^0} , $m_{H_2^0} = 0.4\text{--}1.4 \text{ TeV}$ for different assumptions on width over mass.
- 24 AAD 24BQ search for the decay chain $H \rightarrow A^0 A^0 \rightarrow b\bar{b}\tau^+\tau^-$, produced by gluon fusion, vector boson fusion, or in association with a weak vector boson, in 140 fb^{-1} of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$. See their Fig. 10 for limits on the product of branching ratios in the range $m_{A^0} = 12\text{--}60 \text{ GeV}$.
- 25 AAD 24BV search for H_2^0 produced by vector-boson fusion, decaying to $HH \rightarrow b\bar{b}b\bar{b}$, using 140 fb^{-1} of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$. See their Fig. 8 for limits on the product of production cross section times branching ratios for $m_{H_2^0} = 1\text{--}5 \text{ TeV}$.
- 26 AAD 24BW search for production of H_3^0 decaying to $H_2^0 H$, $H_2^0 \rightarrow W^+W^-$ or ZZ , and $H \rightarrow \gamma\gamma$ using 140 fb^{-1} of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$. See their Figs. 6–8 for limits on production cross section times branching ratios in the ranges $m_{H_3^0} = 0.3\text{--}1.0 \text{ TeV}$ and $m_{H_2^0} = 0.17\text{--}0.5 \text{ TeV}$.
- 27 AAD 24BX search for production of H_4^0 decaying to $H_2^0 H_3^0$, $H_2^0 \rightarrow$ invisible, and $H_3^0 \rightarrow ZZ \rightarrow 4\ell$, using 139 fb^{-1} of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$. See their Fig. 8 (a),

- (b) for limits on production cross section times branching ratios in the ranges $m_{H_4^0} = 0.39\text{--}1.3$ TeV, $m_{H_3^0} = 0.22\text{--}1.0$ TeV, and $m_{H_2^0} = 160$ GeV.
- 28 AAD 24BX search for production of A^0 decaying to $H_2^0 Z$, $H_2^0 \rightarrow ZZ$, resulting in 4ℓ final states, using 139 fb^{-1} of pp collisions at $E_{\text{cm}} = 13$ TeV. See their Fig. 8 (c), (d) for limits on production cross section times branching ratios in the ranges $m_{A^0} = 0.32\text{--}1.3$ TeV and $m_{H_2^0} = 0.22\text{--}1.0$ TeV.
- 29 AAD 24CA search for production of H_3^0 decaying to $H_{1,2}^0 H$, $H_{1,2}^0 \rightarrow b\bar{b}$, and $H \rightarrow \gamma\gamma$ using 140 fb^{-1} of pp collisions at $E_{\text{cm}} = 13$ TeV. See their Fig. 4 for limits on production cross section times branching ratios in the ranges $m_{H_3^0} = 0.17\text{--}1.0$ TeV and $m_{H_{1,2}^0} = 0.015\text{--}0.5$ TeV.
- 30 AAD 24CD search for production of H_2^0 decaying to ZA , $A \rightarrow$ invisible, using 140 fb^{-1} of pp collisions at $E_{\text{cm}} = 13$ TeV. See their Figs. 8–12 for excluded parameter regions in two-Higgs-doublet plus singlet pseudoscalar model.
- 31 AAD 24CF search for gluon-fusion production of A^0 decaying to $\tau^+\tau^-$ in 140 fb^{-1} of pp collisions at $E_{\text{cm}} = 13$ TeV. See their Fig. 7 for limits on cross section times branching ratio in the range $m_{A^0} = 20\text{--}90$ GeV, and Fig. 8 for A^0 coupling with the top quark.
- 32 AAD 24CI search for production of H_2^0 , A^0 decaying to invisible final states, in various channels including $t\bar{t} +$ missing E_T and $t\bar{t}t\bar{t}$, using up to 140 fb^{-1} of pp collisions at $E_{\text{cm}} = 13$ TeV. See their Fig. 3 for cross section limits in a simplified model with fixed Dark Matter mass and couplings to quarks and Dark Matter.
- 33 AAD 24CK combines published ATLAS data up to 139 fb^{-1} to constrain two-Higgs-doublet plus singlet pseudoscalar model with A_1^0 decaying to invisibly into Dirac Dark Matter final states. See their Figs. 4–9 for excluded parameter regions.
- 34 AAD 24H combine searches for a scalar resonance decaying to HH using up to 139 fb^{-1} of pp collisions at $E_{\text{cm}} = 13$ TeV from AAD 22F, AAD 23Z, and AAD 22Y. See their Fig. 1 for limits on cross section times branching ratio for $m_{H_2^0} = 0.251\text{--}5.0$ TeV.
- 35 AAD 24K search for the decay $H \rightarrow ZA^0$ with $A^0 \rightarrow \gamma\gamma$ and $Z \rightarrow \ell^+\ell^-$ in 139 fb^{-1} of pp collisions at $E_{\text{cm}} = 13$ TeV. Merged $\gamma\gamma$ events as well as resolved ones are looked for. See their Fig. 3 for limits on the product of the branching ratios for $m_{A^0} = 0.1\text{--}33$ GeV.
- 36 ADACHI 24F search for H_1^0 , which couples preferentially to muon pairs, in the process $e^+e^- \rightarrow \mu^+\mu^-H_1^0 \rightarrow \mu^+\mu^-\mu^+\mu^-$ using 178 fb^{-1} of e^+e^- collisions at $E_{\text{cm}} = 10.58$ GeV. See their Fig. 13 (lower) for limits on cross section times branching ratio for $m_{H_1^0} = 0.212\text{--}9.0$ GeV. Limits on the model parameter are given in Fig. 14 (lower).
- 37 HAYRAPETYAN 24AA search for the decay chain $H \rightarrow A^0 A^0 \rightarrow b\bar{b}b\bar{b}$, produced in association with W^\pm or Z , in 138 fb^{-1} of pp collisions at $E_{\text{cm}} = 13$ TeV. See their Fig. 3 for limits on the product of branching ratios in the range $m_{A^0} = 15\text{--}60$ GeV.
- 38 HAYRAPETYAN 24AE search for $H_2^0 \rightarrow HH$ in the final state $b\bar{b}W^+W^-$ using 138 fb^{-1} of pp collisions at $E_{\text{cm}} = 13$ TeV. See their Fig. 19 (upper) for limit on the product of production cross section times branching ratios for $m_{H_2^0} = 0.25\text{--}0.9$ TeV.
- 39 HAYRAPETYAN 24AF search for $H \rightarrow A^0 A^0$ in the final state $b\bar{b}\mu^+\mu^-$ and $b\bar{b}\tau^+\tau^-$ in 138 fb^{-1} of pp collisions at $E_{\text{cm}} = 13$ TeV. See their Figs. 10, 11, and 12 for limits on the product of branching ratios in the range $m_{A^0} = 12\text{--}60$ GeV. Interpretation of the limits in terms of two Higgs doublet plus singlet models is given in their Figs. 13 and 14.

- 40 HAYRAPETYAN 24AI search for $H \rightarrow H_1^0 H_1^0$, with long-lived H_1^0 decaying in the muon detectors to $\gamma\gamma$, e^+e^- , $\pi^0\pi^0$, $\pi^+\pi^-$, K^+K^- , $K^0\bar{K}^0$, $d\bar{d}$, $\tau^+\tau^-$, or $b\bar{b}$, using 138 fb^{-1} of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$. See their Figs. 13–17 for limits on $B(H \rightarrow H_1^0 H_1^0)$ in the mass range between 0.4 and 55 GeV for each of the decay modes.
- 41 HAYRAPETYAN 24AJ search for production of a scalar resonance decaying to $\gamma\gamma$ in 138 fb^{-1} of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$. See their Fig. 3 (right) for limits on production cross section times branching ratio for $m_{H_2^0} = 0.6\text{--}5.0 \text{ TeV}$, and Fig. 4 (lower) for their dependence on the width.
- 42 HAYRAPETYAN 24AZ search for pair production of A^0 decaying to $\mu^+\mu^-$ using $101\text{--}137 \text{ fb}^{-1}$ of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$. See their Fig. 5 for limits on cross section times branching ratio for $m_{A^0} = 0.21\text{--}60 \text{ GeV}$.
- 43 HAYRAPETYAN 24AZ search for H or $H_{1,2}^0$ decaying to $A^0 A^0 \rightarrow \mu^+\mu^-\mu^+\mu^-$ using $101\text{--}137 \text{ fb}^{-1}$ of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$. See their Fig. 8 for limits on cross section times branching ratio for $m_{A^0} = 0.5\text{--}2.7 \text{ GeV}$ and several choices of $m_{H_{1,2}^0}$ in a NMSSM scenario.
- 44 HAYRAPETYAN 24I search for the decay $H \rightarrow ZA^0$ with $A^0 \rightarrow \gamma\gamma$ and $Z \rightarrow \ell^+\ell^-$ in 138 fb^{-1} of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$. See their Fig. 7 for limits on the product of cross section times the branching ratios for $m_{A^0} = 1\text{--}30 \text{ GeV}$.
- 45 TUMASYAN 24A search for production of $H_{1,2}^0$ in association with W , Z , or $t\bar{t}$, decaying to e^+e^- , $\mu^+\mu^-$, or $\tau^+\tau^-$, using 138 fb^{-1} of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$. See their Fig. 13 for limits on cross section times branching ratio for $m_{H_{1,2}^0} = 15\text{--}350 \text{ GeV}$.
See also Figs. 16 and 17 for limits on the mixing with the Standard Model Higgs boson.
- 46 TUMASYAN 24B search for $H_2^0 \rightarrow HH$ in the final state $\gamma\gamma b\bar{b}$ using 138 fb^{-1} of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$. See their Fig. 6 (upper) for limit on the product of production cross section times branching ratios for $m_{H_2^0} = 0.26\text{--}1.0 \text{ TeV}$.
- 47 TUMASYAN 24B search for production of H_3^0 decaying to $H_{1,2}^0 H \rightarrow b\bar{b}\gamma\gamma$ using 138 fb^{-1} of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$. See their Fig. 7 for limits on production cross section times branching ratios for $m_{H_3^0} = 0.3\text{--}1.0 \text{ TeV}$ and $m_{H_{1,2}^0} = 0.09\text{--}0.8 \text{ TeV}$.
- 48 AAD 23AD search for associated production of $W/Z H_2^0$ with the decay chain $H_2^0 \rightarrow HH \rightarrow b\bar{b}b\bar{b}$ using 139 fb^{-1} of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$. See their Fig. 9 for limits on cross section times branching ratios for $m_{H_2^0} = 260\text{--}1000 \text{ GeV}$.
- 49 AAD 23AD search for gluon fusion production of A^0 with the decay chain $A^0 \rightarrow Z H_2^0$, $H_2^0 \rightarrow HH \rightarrow b\bar{b}b\bar{b}$ using 139 fb^{-1} of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$. See their Fig. 10 for limits on cross section times branching ratios for $m_{A^0} = 350\text{--}800 \text{ GeV}$ and $m_{H_2^0} = 260\text{--}400 \text{ GeV}$.
- 50 AAD 23AJ search for production of H^\pm in association with a top quark, followed by $H^\pm \rightarrow W^\pm A^0$, $A^0 \rightarrow$ invisible, using 139 fb^{-1} of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$. See their Fig. 10 for excluded parameter regions of 2HDM + CP -odd singlet model.
- 51 AAD 23BD search for a top quark decaying to $q H_{1,2}^0$ ($q = u, c$), $H_{1,2}^0 \rightarrow b\bar{b}$, using 139 fb^{-1} of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$. See their Fig. 9 for limits on production cross section times branching ratios for $m_{H_{1,2}^0} = 20\text{--}160 \text{ GeV}$.
- 52 AAD 23BE search for associated production of $H_2^0 W$ and decay $H_2^0 \rightarrow W^+W^-$ assuming the presence of higher dimensional $H_2^0 W^+W^-$ interactions, using 139 fb^{-1} of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$. See their Fig. 6 for excluded parameter region of higher

dimensional operators, and Fig. 7 for limits on cross section times branching ratio for $m_{H_2^0} = 0.3\text{--}1.5$ TeV.

- 53 AAD 23BG search for production of H_2^0/A^0 in association with a $t\bar{t}$ pair, decaying to $t\bar{t}$, resulting in final states with two same-sign leptons or three or more leptons, using 139 fb^{-1} of pp collisions at $E_{\text{cm}} = 13$ TeV. See their Fig. 7 (corrected version in the erratum) for limits on cross section times branching ratios for $m_{H_2^0}$ and/or $m_{A^0} = 0.4\text{--}1.0$ TeV.
- 54 AAD 23BW search for A^0 production in association with a $t\bar{t}$ pair, decaying to $\mu^+\mu^-$, using 139 fb^{-1} of pp collisions at $E_{\text{cm}} = 13$ TeV. See their Fig. 5(a) for limits on production cross section times branching ratio for $m_{A^0} = 15\text{--}72$ GeV.
- 55 AAD 23BX search for production of $H \rightarrow \tau^+\tau^-$ with missing transverse momentum using 139 fb^{-1} of pp collisions at $E_{\text{cm}} = 13$ TeV. See their Fig. 8 for interpretation of the data in terms of 2HDM + a model.
- 56 AAD 23CA search for production of H_3^0 decaying to $H_2^0 H$, $H_2^0 \rightarrow W^+W^-$ or ZZ , and $H \rightarrow \tau^+\tau^-$ using 140 fb^{-1} of pp collisions at $E_{\text{cm}} = 13$ TeV. See their Figs. 4, 5 for limits on production cross section times branching ratios in the ranges $m_{H_3^0} = 0.5\text{--}1.5$ TeV and $m_{H_2^0} = 0.2\text{--}0.5$ TeV.
- 57 AAD 23CR search for H_2^0 having flavor-violating couplings to tc or tu , produced in association with top quark(s), using 139 fb^{-1} of pp collisions at $E_{\text{cm}} = 13$ TeV. See their Fig. 14 for limits on production cross section times branching ratios for $m_{H_2^0} = 0.2\text{--}1.5$ TeV with various assumptions on the flavor-changing couplings.
- 58 AAD 23O search for production of an A^0 in gluon-gluon fusion and in association with a $b\bar{b}$, decaying to ZH in the final states $\nu\bar{\nu}b\bar{b}$ and $\ell^+\ell^-b\bar{b}$ using 139 fb^{-1} of pp collisions at $E_{\text{cm}} = 13$ TeV. See their Fig. 9 for limits on cross section times branching ratio for $m_{A^0} = 0.22\text{--}2.0$ TeV, and Fig. 11 for limits with both production components.
- 59 AAD 23R search for the decay $A^0 \rightarrow \gamma\gamma$ in 138 fb^{-1} of pp collisions at $E_{\text{cm}} = 13$ TeV. See their Fig. 7 for limits on cross section times branching ratio for $m_{A^0} = 10\text{--}70$ GeV.
- 60 AAD 23U search for the decay $H_2^0 \rightarrow Z\gamma$ with Z decaying hadronically in 139 fb^{-1} of pp collisions at $E_{\text{cm}} = 13$ TeV. See their Fig. 8(a) for limits on production cross section times branching ratios for $m_{H_2^0} = 1.0\text{--}6.8$ TeV.
- 61 AAD 23Z search for the decay chain $H_2^0 \rightarrow HH \rightarrow b\bar{b}\tau^+\tau^-$ using 139 fb^{-1} of pp collisions at $E_{\text{cm}} = 13$ TeV. See their Fig. 10 for limits on the product of production cross section times branching ratios for $m_{H_2^0} = 0.251\text{--}1.6$ TeV.
- 62 HAYRAPETYAN 23C search for $H_{1,2}^0 \rightarrow e\mu$ using 138 fb^{-1} of pp collisions at $E_{\text{cm}} = 13$ TeV. See their Fig. 7 for limits on production cross section times branching ratio for $m_{H_{1,2}^0} = 110\text{--}160$ GeV.
- 63 HAYRAPETYAN 23G search for dimuon resonance in the mass range $1.1\text{--}2.6$ or $4.2\text{--}7.9$ GeV in 96.6 fb^{-1} of pp collisions at $E_{\text{cm}} = 13$ TeV, in inclusive and high p_T selections. See their Fig. 5 for cross section times branching ratio limits and Fig. 7 for mixing angle limits in two Higgs doublet plus singlet model (at 90% CL).
- 64 TUMASYAN 23 search for production of H_3^0 decaying to $H_{1,2}^0 H \rightarrow b\bar{b}b\bar{b}$ using 138 fb^{-1} of pp collisions at $E_{\text{cm}} = 13$ TeV. See their Fig. 4 for limits on production cross section times branching ratios for $m_{H_3^0} = 0.9\text{--}4.0$ TeV and $m_{H_{1,2}^0} = 60\text{--}600$ GeV, and their interpretation in the NMSSM and the Two Real Singlet Model (TRSM).

- 65 TUMASYAN 23M search for the decay chain $H \rightarrow A^0 A^0 \rightarrow \gamma\gamma\gamma\gamma$ in 132 fb^{-1} of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$. See their Fig. 6 for limits on cross section times branching ratio in the range $m_{A^0} = 15\text{--}62 \text{ GeV}$.
- 66 TUMASYAN 23O search for $H_2^0 \rightarrow HH$, each H decaying to either WW^* or $\tau^+\tau^-$ using 138 fb^{-1} of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$. See their Fig. 14 (upper) for limit on the product of production cross section times branching ratios for $m_{H_2^0} = 0.25\text{--}1.0 \text{ TeV}$.
- 67 TUMASYAN 23S search for gluon fusion and b -associated production of $H_{1,2}^0$ decaying to $\tau^+\tau^-$ using 138 fb^{-1} of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$. See their Fig. 10 for limits on production cross section times branching ratios for $m_{H_{1,2}^0} = 0.06\text{--}3.5 \text{ TeV}$.
- 68 AAD 22A search for the decay chain $H \rightarrow A^0 A^0 \rightarrow \mu^+\mu^- b\bar{b}$ in 139 fb^{-1} of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$. See their Fig. 9 for limits on the overall branching fraction in the range $m_{A^0} = 16\text{--}62 \text{ GeV}$. See also Fig. 11 for limits without assuming A^0 is pseudoscalar.
- 69 AAD 22D search for ZA^0 associate production with $Z \rightarrow \ell^+\ell^-$, A^0 decaying invisibly, in 139 fb^{-1} of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$. See their Fig. 5 for excluded regions in the mass parameter space of two Higgs doublet plus singlet (2HDM+ A^0) model with a certain choice of the model parameters.
- 70 AAD 22F search for gluon fusion production of H_2^0 decaying to $HH \rightarrow b\bar{b}b\bar{b}$ using $126\text{--}139 \text{ fb}^{-1}$ of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$. $B(H \rightarrow b\bar{b}) = 0.582$ is assumed. See their Fig. 14 for limit on the product of production cross section times branching ratios for $m_{H_2^0} = 0.251\text{--}5.0 \text{ TeV}$.
- 71 AAD 22I search for ZH associate production with the decay chain $H \rightarrow \tilde{\chi}_2^0 \tilde{\chi}_1^0, \tilde{\chi}_2^0 \rightarrow A^0 \tilde{\chi}_1^0, A^0 \rightarrow b\bar{b}$, and $Z \rightarrow \ell^+\ell^-$, in 139 fb^{-1} of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$. See their Figs. 3 and 4 for limits on the product of cross section times the branching ratios for $m_{A^0} = 20\text{--}65 \text{ GeV}$ with various choices of NMSSM model parameters.
- 72 AAD 22J search for the decay $H \rightarrow ZA^0$ with $A^0 \rightarrow \mu^+\mu^-$ and $Z \rightarrow e^+e^-$, $\mu^+\mu^-$ in 139 fb^{-1} of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$ assuming SM gluon-gluon fusion production of the H . See their Fig. 17(b) for limits on the product of cross section times the branching ratios for $m_{A^0} = 15\text{--}30 \text{ GeV}$.
- 73 AAD 22J search for the decay $H \rightarrow A^0 A^0$ with $A^0 \rightarrow \mu^+\mu^-$ in 139 fb^{-1} of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$ assuming SM gluon-gluon fusion production of the H in the range of $m_{A^0} = 1\text{--}60 \text{ GeV}$. See their Fig. 14(b) for limits on the product of cross section times the branching ratios for $m_{A^0} = 1.5\text{--}60 \text{ GeV}$ (excluding ψ and Υ regions). The limit also applies to the decay $H \rightarrow H_1^0 H_1^0$.
- 74 AAD 22P search for invisibly decaying H_1^0, H_2^0 produced by vector boson fusion in 139 fb^{-1} of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$. Limit on the product of cross section times branching ratio in the range $0.1\text{--}1 \text{ pb}$ (95% CL) is given for the mass range $0.05\text{--}2 \text{ TeV}$. See their Fig. 14.
- 75 AAD 22Y search for gluon fusion production of H_2^0 decaying to $HH \rightarrow b\bar{b}\gamma\gamma$ in 139 fb^{-1} of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$. See their Fig. 15 for limit on the product of production cross section times branching ratios to HH for $m_{H_2^0} = 0.251\text{--}1.0 \text{ TeV}$.
- 76 ABRATENKO 22A search for a singlet scalar boson H_1^0 having a small mixing with the SM Higgs boson in the decay chain $K^+ \rightarrow H_1^0 \pi^+, H_1^0 \rightarrow \mu^+\mu^-$ from data corresponding to 7.01×10^{20} protons on NuMI target. See their Fig. 13 (right) and Table V for limits on the SM Higgs component of H_1^0 for $m_{H_1^0} = 212\text{--}279 \text{ MeV}$.

- 77 TUMASYAN 22AK search for gluon-fusion production of H_3^0 decaying to $H_1^0 H_1^0 \rightarrow b\bar{b}b\bar{b}$ in 137 fb^{-1} of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$. See their Fig. 5 for limits on cross section times branching ratio for $m_{H_3^0} = 1\text{--}3 \text{ TeV}$, $m_{H_1^0} = 25\text{--}100 \text{ GeV}$.
- 78 TUMASYAN 22D search for production of an H_2^0 (denoted radion in the paper) in gluon fusion and vector boson fusion, decaying to $W^+ W^-$ in the final states $\ell\nu + \text{hadrons}$, using 137 fb^{-1} of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$. See their Fig. 7 for limits on cross section times branching ratio for $m_{H_2^0} = 1.0\text{--}4.5 \text{ TeV}$.
- 79 AAD 21AF search for production of a heavy H_2^0 state decaying to ZZ in the final states $\ell^+ \ell^- \ell'^+ \ell'^-$ and $\ell^+ \ell^- \nu\bar{\nu}$ in 139 fb^{-1} of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$. See their Fig. 4 for upper limits on cross section times branching ratio for $m_{H_2^0} = 0.2\text{--}2.0 \text{ TeV}$ assuming ggF or VBF with narrow width approximation, and Fig. 5 for upper limits on cross section times branching ratio for $m_{H_2^0} = 0.4\text{--}2.0 \text{ TeV}$ assuming ggF, and with several assumptions on its width.
- 80 AAD 21AI search for production of an A^0 in gluon-gluon fusion and in association with a $b\bar{b}$, decaying to $ZH_2^0 \rightarrow \ell^+ \ell^- b\bar{b}$ or $\ell^+ \ell^- W^+ W^-$ in 139 fb^{-1} of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$. See their Figs. 9 and 13 for cross section limits for $m_{A^0} = 230\text{--}800 \text{ GeV}$ and $m_{H_2^0} = 130\text{--}700 \text{ GeV}$.
- 81 AAD 21AY search for production of a scalar resonance decaying to $\gamma\gamma$ in 139 fb^{-1} of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$. See their Fig. 5(a) for limits on fiducial cross section times branching ratio for $m_{H_2^0} = 0.16\text{--}3 \text{ TeV}$ with narrow width approximation, and Table 2 with several assumptions on the width.
- 82 AAD 21AZ search for production of A_2^0 decaying to HA_1^0 followed by $H \rightarrow \gamma\gamma$, $A_1^0 \rightarrow$ invisible in 139 fb^{-1} of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$. See their Figs. 10–12 for limits in terms of two-Higgs-doublet model plus singlet pseudoscalar and a fermionic Dark Matter particle.
- 83 AAD 21BB search for production of A_2^0 by gluon fusion or associated $A_2^0 b\bar{b}$ production, decaying to HA_1^0 followed by $H \rightarrow b\bar{b}$, $A_1^0 \rightarrow$ invisible in 139 fb^{-1} of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$. See their Fig. 8 for limits in terms of two-Higgs-doublet plus singlet pseudoscalar model.
- 84 AAD 21BE search for production of A_1^0 associated with a single top quark and either a light quark or a W boson, decaying to invisible final states, in 139 fb^{-1} of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$. See their Figs. 13–15 for limits in terms of two-Higgs-doublet model plus singlet pseudoscalar, which is assumed to decay to a pair of Dark Matter particles.
- 85 ABRATENKO 21 search for a singlet scalar boson H_1^0 having a small mixing with the SM Higgs boson in the decay chain $K^+ \rightarrow H_1^0 \pi^+$, $H_1^0 \rightarrow e^+ e^-$ from data corresponding to 1.93×10^{20} protons on NuMI target. See their Fig. 2 for limits on the SM Higgs component of H_1^0 for $m_{H_1^0} = 3\text{--}210 \text{ MeV}$.
- 86 SIRUNYAN 21A search for $H_2^0 \rightarrow ZA^0$ with $Z \rightarrow \ell^+ \ell^-$, A^0 decaying invisibly, in 137 fb^{-1} of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$. See their Fig. 8 for excluded regions in the mass parameter space of two Higgs doublet plus singlet model with a certain choice of the model parameters.
- 87 TUMASYAN 21F search for gluon fusion production of H_3^0 decaying to $HH_{1,2}^0 \rightarrow \tau^+ \tau^- b\bar{b}$ in 137 fb^{-1} of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$. See their Figs. 5 and 6 for limits on cross section times branching ratios for $m_{H_{1,2}^0} = 0.06\text{--}2.8 \text{ TeV}$ and $m_{H_3^0} = 0.24\text{--}3.0 \text{ TeV}$.

- 88 AAD 20AA search for $H_2^0/A^0 \rightarrow \tau^+\tau^-$ produced by gluon fusion or b -associated production using 139 fb^{-1} of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$. See their Fig. 2(a), 2(b) for limits on the product of cross section and branching ratio for $m_{H_2^0}, m_{A^0} = 0.2\text{--}2.5 \text{ TeV}$.
- 89 AAD 20AI search for ZH production followed by the decay $H \rightarrow A^0 A^0 \rightarrow b\bar{b}b\bar{b}$ in 36 fb^{-1} of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$. The search looks for collimated $A^0 \rightarrow b\bar{b}$ decays and is complementary to AABOUD 18BX. See their Fig. 10 for limits on the product of production cross section and branching ratios in the range $m_{A^0} = 15\text{--}30 \text{ GeV}$.
- 90 AAD 20AO search for gluon fusion production of H_2^0 decaying to $HH \rightarrow \tau^+\tau^- b\bar{b}$ (with hadronically decaying $\tau^+\tau^-$) using 139 fb^{-1} of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$. Limit on the product of production cross section times branching ratios in the range $28\text{--}817 \text{ fb}$ (95% CL) is given for $m_{A^0} = 1.0\text{--}3.0 \text{ TeV}$, see their Fig. 13.
- 91 AAD 20C combine searches for a scalar resonance decaying to HH in 36.1 fb^{-1} of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$ from AABOUD 19A, AABOUD 190, AABOUD 18CQ, AABOUD 19T, AABOUD 18CW, and AABOUD 18BU. See their Fig. 5(a) for limits on cross section times branching ratio for $m_{H_2^0} = 0.26\text{--}3 \text{ TeV}$.
- 92 AAD 20L search for b -associated production of H_2^0 decaying to $b\bar{b}$ in 27.8 fb^{-1} of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$. See their Fig. 8 for limits on the product of cross section and branching ratio for $m_{H_2^0} = 0.45\text{--}1.4 \text{ TeV}$.
- 93 AAD 20X search for vector-boson-fusion production of H_2^0 decaying to HH using 126 fb^{-1} of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$. See their Fig. 5 for limits on the product of cross section and branching ratio for the assumptions of a narrow- and broad-width resonance.
- 94 AAIJ 20AL search for dimuon resonance in the mass range $0.2\text{--}60 \text{ GeV}$ in 5.1 fb^{-1} of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$, in inclusive and b quark associated production. Displaced decays are searched for for masses below 3 GeV . See their Figs. 7–9 for cross section limits and Fig. 10 for limits for mixing angle in two Higgs doublet plus singlet model (at 90% CL).
- 95 SIRUNYAN 20 search for the decay $H \rightarrow A^0 A^0 \rightarrow \tau^+\tau^-\tau^+\tau^-$ or $\tau^+\tau^-\mu^+\mu^-$ in 35.9 fb^{-1} of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$. See their Fig. 10 for limits on the product of production cross section (normalized to the SM) and branching ratios in the range $m_{A^0} = 4\text{--}15 \text{ GeV}$.
- 96 SIRUNYAN 20AA search for $H_2^0 \rightarrow ZA^0, A^0 \rightarrow b\bar{b}$ or $A^0 \rightarrow ZH_2^0, H_2^0 \rightarrow b\bar{b}$ in 35.9 fb^{-1} of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$. See their Fig. 7 for limits on the product of cross section and branching ratio for $m_{H_2^0} = 0.12\text{--}1 \text{ TeV}$ and $m_{A^0} = 0.03\text{--}1 \text{ TeV}$.
- 97 SIRUNYAN 20AC search for gluon-fusion production of A^0 decaying to ZH in 35.9 fb^{-1} of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$. See their Fig. 5 for limits on the product of cross section and branching ratios for $m_{A^0} = 220\text{--}400 \text{ GeV}$.
- 98 SIRUNYAN 20AD search for lepton-flavor violating decays $H_2^0 \rightarrow \mu\tau, e\tau$ of gluon-fusion-produced H_2^0 in 35.9 fb^{-1} of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$. See their Fig. 5 (9) and Table 5 (6) for limits on production cross section times branching ratio for $m_{H_2^0} = 0.2\text{--}0.9 \text{ TeV}$ for the $\mu\tau$ ($e\tau$) final state.
- 99 SIRUNYAN 20AF search for $H_2^0/A^0 \rightarrow t\bar{t}$ with one or two charged leptons in the final state using kinematic variables in 35.9 fb^{-1} of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$. See their Figs. 5 and 6 for limits on top Yukawa coupling of H_2^0 and A^0 for $m_{H_2^0}, m_{A^0} = 0.4\text{--}0.75 \text{ TeV}$ for various width assumptions.

- 100 SIRUNYAN 20AP search for the decay H or $H_2^0 \rightarrow A^0 A^0 \rightarrow \mu^+ \mu^- \tau^+ \tau^-$ (for $m_{H_2^0} = 300$ GeV) with boosted final-state topology in 35.9 fb^{-1} of pp collisions at $E_{\text{cm}} = 13$ TeV. See their Fig. 7 for limits on the product of production cross section (normalized to the SM) and branching ratios in the range $m_{A^0} = 3.6\text{--}21$ GeV, and Figs. 8 and 9 for its interpretation in terms of models with two Higgs doublets plus a singlet.
- 101 SIRUNYAN 20Y search for gluon-fusion and vector-boson-fusion production of H_2^0 decaying to $W^+ W^-$ in the final states $\ell\nu\ell\nu$ and $\ell\nu qq$ in 35.9 fb^{-1} of pp collisions at $E_{\text{cm}} = 13$ TeV. See their Fig. 6 for limits on the product of cross section and branching ratio for $m_{H_2^0} = 0.2\text{--}3$ TeV.
- 102 SIRUNYAN 20Z search for $H_{1,2}^0$ or A^0 production in association with a $t\bar{t}$ pair, decaying to $e^+ e^-$ or $\mu^+ \mu^-$, in 137 fb^{-1} of pp collisions at $E_{\text{cm}} = 13$ TeV. See their Fig. 12 for limits on production cross section times branching ratio for $m_{H_{1,2}^0}$, $m_{A^0} = 15\text{--}75$ GeV and $108\text{--}340$ GeV.
- 103 AABOUD 19A search for a narrow scalar resonance decaying to $HH \rightarrow b\bar{b}b\bar{b}$ in $27.5\text{--}36.1 \text{ fb}^{-1}$ of pp collisions at $E_{\text{cm}} = 13$ TeV. See their Fig. 9(a) for limits on cross section times branching ratios for $m_{H_2^0} = 0.26\text{--}3$ TeV.
- 104 AABOUD 19AG search for the decay $H \rightarrow A^0 A^0 \rightarrow \mu^+ \mu^- b\bar{b}$ in 36.7 fb^{-1} of pp collisions at $E_{\text{cm}} = 13$ TeV. See their Fig. 6 (a) for limits on the product of production cross section (normalized to the SM) and branching ratios in the range $m_{A^0} = 20\text{--}60$ GeV.
- 105 AABOUD 19O search for a scalar resonance decaying to $HH \rightarrow b\bar{b}WW^*$ in 36.1 fb^{-1} of pp collisions at $E_{\text{cm}} = 13$ TeV. See their Fig. 12 (left) for limits on cross section times branching ratio for $m_{H_2^0} = 0.5\text{--}3$ TeV.
- 106 AABOUD 19T search for a scalar resonance decaying to $HH \rightarrow WW^*WW^*$ in 36.1 fb^{-1} of pp collisions at $E_{\text{cm}} = 13$ TeV. See their Fig. 3 for limits on cross section times branching ratio for $m_{H_2^0} = 260\text{--}500$ GeV, assuming SM decay rates for the H .
- 107 AABOUD 19V combine published ATLAS data to constrain two-Higgs-doublet plus singlet pseudoscalar model with A_1^0 decaying to invisible final states. See their Fig. 19 for excluded parameter regions.
- 108 AABOUD 19Y search for a narrow scalar resonance produced by gluon fusion or b associated production, decaying to $\mu^+ \mu^-$ in 36.1 fb^{-1} of pp collisions at $E_{\text{cm}} = 13$ TeV. See their Figs. 4 and 5(a) for cross section limits for $m_{H_2^0} = 0.2\text{--}1.0$ TeV.
- 109 AALTONEN 19 search for b associated production of a scalar particle decaying to $b\bar{b}$ in 5.4 fb^{-1} of $p\bar{p}$ collisions at $E_{\text{cm}} = 1.96$ TeV. See their Fig. 3 for limits on cross section times branching ratio for $m_{H_{1,2}^0} = 100\text{--}300$ GeV.
- 110 SIRUNYAN 19 search for a narrow scalar resonance decaying to $HH \rightarrow \gamma\gamma b\bar{b}$ in 35.9 fb^{-1} of pp collisions at $E_{\text{cm}} = 13$ TeV. See their Fig. 9 (left) for limits on cross section times branching ratios for $m_{H_2^0} = 260\text{--}900$ GeV.
- 111 SIRUNYAN 19AE search for a scalar resonance produced in association with a $b\bar{b}$ pair, decaying to $\tau^+ \tau^-$ in 35.9 fb^{-1} of pp collisions at $E_{\text{cm}} = 13$ TeV. See their Fig. 4 for cross section limits for $m_{A^0} = 25\text{--}70$ GeV.
- 112 SIRUNYAN 19AN search for production of A_2^0 decaying to HA_1^0 followed by $H \rightarrow b\bar{b}$, $A_1^0 \rightarrow$ invisible in 35.9 fb^{-1} of pp collisions at $E_{\text{cm}} = 13$ TeV, in the mass range $m_{A_2^0} = 0.2\text{--}1.6$ TeV, $m_{A_1^0} = 0.15\text{--}0.5$ TeV. See their Fig. 6 for limits in terms of two-Higgs-doublet plus singlet pseudoscalar model.

- 113 SIRUNYAN 19AV search for a scalar resonance produced by gluon fusion or b -associated production, decaying to $ZH \rightarrow \ell^+ \ell^- b \bar{b}$ ($\ell = e, \mu$) or $\nu \bar{\nu} b \bar{b}$ in 35.9 fb^{-1} of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$. See their Fig. 5 for cross section limits for $m_{A^0} = 0.22\text{--}1.0 \text{ TeV}$.
- 114 SIRUNYAN 19B search for gluon fusion production of narrow scalar resonance with large transverse momentum, decaying to $b \bar{b}$, in 35.9 fb^{-1} of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$. See their Figs. 7 and 8 for limits on cross section times branching ratio for the resonance mass of $50\text{--}350 \text{ GeV}$.
- 115 SIRUNYAN 19BB search for the decay $H_1^0 \rightarrow \gamma\gamma$ in 19.7 fb^{-1} of pp collisions at $E_{\text{cm}} = 8 \text{ TeV}$ and 35.9 fb^{-1} at $E_{\text{cm}} = 13 \text{ TeV}$. See their Figs. 4–6 for limits on cross section times branching ratio for $m_{H_1^0} = 80\text{--}110 \text{ GeV}$ (some results in Fig. 5 for $m_{H_1^0} = 70\text{--}110 \text{ GeV}$).
- 116 SIRUNYAN 19BD search for the decay $H \rightarrow A^0 A^0 \rightarrow \mu^+ \mu^- b \bar{b}$ in 35.9 fb^{-1} of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$. See their Fig. 5 for limits on the product of cross section times branching ratios in the range $m_{A^0} = 20\text{--}62.5 \text{ GeV}$. See also their Figs. 6 and 7 for interpretation of the data in terms of models with two Higgs doublets and a singlet.
- 117 SIRUNYAN 19BE combine searches for $H_2^0 \rightarrow HH$ in 35.9 fb^{-1} of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$ in various H decay modes, from SIRUNYAN 18A, SIRUNYAN 18AF, SIRUNYAN 18CW, SIRUNYAN 19, and SIRUNYAN 19H. See their Fig. 3 for limits on cross section times branching ratios for $m_{H_2^0} = 0.25\text{--}3 \text{ TeV}$.
- 118 SIRUNYAN 19BQ search for production of $H_{1,2}^0$ decaying to $A^0 A^0 \rightarrow \mu^+ \mu^- \mu^+ \mu^-$ in 35.9 fb^{-1} of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$. See their Fig. 2 for limits on cross section times branching ratio for $m_{H_{1,2}^0} = 90\text{--}150 \text{ GeV}$, $m_{A^0} = 0.25\text{--}3.55 \text{ GeV}$.
- 119 SIRUNYAN 19CR search for production of H_2^0/A^0 in gluon fusion and in association with a $b \bar{b}$ pair, decaying to $\mu^+ \mu^-$ in 35.9 fb^{-1} of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$. See their Fig. 6 for limits on cross section times branching ratio.
- 120 SIRUNYAN 19H search for a narrow scalar resonance decaying to $HH \rightarrow b \bar{b} b \bar{b}$ in 35.9 fb^{-1} of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$, where one $b \bar{b}$ pair is resolved and the other not. Limits on cross section times branching ratios for $m_{H_2^0} = 0.75\text{--}1.6 \text{ TeV}$ are obtained and combined with data from SIRUNYAN 18AF. See their Fig. 5 (right).
- 121 AABOUD 18AA search for production of a scalar resonance decaying to $Z\gamma$, with Z decaying hadronically, in 36.1 fb^{-1} of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$. See their Fig. 8(a) for limits on cross section times branching ratio for $m_{H_2^0} = 1.0\text{--}6.8 \text{ TeV}$.
- 122 AABOUD 18AG search for the decay $H \rightarrow A^0 A^0 \rightarrow \gamma\gamma gg$ in 36.7 fb^{-1} of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$. See their Fig. 2 and Table 6 for cross section limits in the range $m_{A^0} = 20\text{--}60 \text{ GeV}$.
- 123 AABOUD 18AH search for production of an A^0 in gluon-gluon fusion and in association with a $b \bar{b}$, decaying to $ZH_2^0 \rightarrow \ell^+ \ell^- b \bar{b}$ in 36.1 fb^{-1} of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$. See their Fig. 5 for cross section limits for $m_{A^0} = 230\text{--}800 \text{ GeV}$ and $m_{H_2^0} = 130\text{--}700 \text{ GeV}$.
- 124 AABOUD 18AI search for production of an A^0 in gluon-gluon fusion and in association with a $b \bar{b}$, decaying to ZH in the final states $\nu \bar{\nu} b \bar{b}$ and $\ell^+ \ell^- b \bar{b}$ in 36.1 fb^{-1} of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$. See their Fig. 6 for cross section limits for $m_{A^0} = 0.2\text{--}2 \text{ TeV}$. See also AABOUD 18CC.
- 125 AABOUD 18BF search for production of a heavy H_2^0 state decaying to ZZ in the final states $\ell^+ \ell^- \ell^+ \ell^-$ and $\ell^+ \ell^- \nu \bar{\nu}$ in 36.1 fb^{-1} of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$. See their Fig. 6 for upper limits on cross section times branching ratio for $m_{H_2^0} = 0.2\text{--}1.2 \text{ TeV}$ assuming ggF or VBF with the NWA. See their Fig. 7 for upper limits on cross

- section times branching ratio for $m_{H_2^0} = 0.4\text{--}1.0$ TeV assuming ggF , and with several assumptions on its width.
- 126 AABOUD 18BU search for a narrow scalar resonance decaying to $HH \rightarrow \gamma\gamma WW^*$ in 36.1 fb^{-1} of pp collisions at $E_{\text{cm}} = 13$ TeV. See their Fig. 4 for limits on cross section times branching ratios for $m_{H_2^0} = 260\text{--}500$ GeV.
- 127 AABOUD 18BX search for associated production of WH or ZH followed by the decay $H \rightarrow A^0 A^0 \rightarrow b\bar{b}b\bar{b}$ in 36.1 fb^{-1} of pp collisions at $E_{\text{cm}} = 13$ TeV. See their Fig. 9 for limits on cross section times branching ratios for $m_{A^0} = 20\text{--}60$ GeV. See also their Fig. 10 for the dependence of the limit on A^0 lifetime.
- 128 AABOUD 18CQ search for a narrow scalar resonance decaying to $HH \rightarrow b\bar{b}\tau^+\tau^-$ in 36.1 fb^{-1} of pp collisions at $E_{\text{cm}} = 13$ TeV. See their Fig. 2 (above) for limits on cross section times branching ratios for $m_{H_2^0} = 260\text{--}1000$ GeV.
- 129 AABOUD 18F search for production of a narrow scalar resonance decaying to W^+W^- and ZZ , followed by hadronic decays of W and Z , in 36.7 fb^{-1} of pp collisions at $E_{\text{cm}} = 13$ TeV. See their Fig. 5(c) for limits on cross section times branching ratio for $m_{H_2^0} = 1.2\text{--}3.0$ TeV.
- 130 AAIJ 18AM search for gluon-fusion production of $H_{1,2}^0$ decaying to $\mu\tau$ in 2 fb^{-1} of pp collisions at $E_{\text{cm}} = 8$ TeV. See their Fig. 2 for limits on cross section times branching ratio for $m_{H_{1,2}^0} = 45\text{--}195$ GeV.
- 131 AAIJ 18AQ search for gluon-fusion production of a scalar particle A^0 decaying to $\mu^+\mu^-$ in 1.99 fb^{-1} of pp collisions at $E_{\text{cm}} = 8$ TeV and 0.98 fb^{-1} at $E_{\text{cm}} = 7$ TeV. See their Fig. 4 for limits on cross section times branching ratio for $m_{A^0} = 5.5\text{--}15$ GeV (using the $E_{\text{cm}} = 8$ TeV data set).
- 132 AAIJ 18AQ search for the decay $H \rightarrow A^0 A^0$, with one of the A^0 decaying to $\mu^+\mu^-$, in 1.99 fb^{-1} of pp collisions at $E_{\text{cm}} = 8$ TeV and 0.98 fb^{-1} at $E_{\text{cm}} = 7$ TeV. See their Fig. 5 (right) for limits on the product of branching ratios for $m_{A^0} = 5.5\text{--}15$ GeV (using the $E_{\text{cm}} = 8$ TeV data set).
- 133 SIRUNYAN 18AF search for a narrow scalar resonance decaying to $HH \rightarrow b\bar{b}b\bar{b}$ in 35.9 fb^{-1} of pp collisions at $E_{\text{cm}} = 13$ TeV, where both $b\bar{b}$ pairs are not resolved. See their Fig. 9 for limits on cross section times branching ratios for $m_{H_2^0} = 0.75\text{--}3$ TeV.
- 134 SIRUNYAN 18BA search for production of a heavy H_2^0 state decaying to ZZ in the final states $\ell^+\ell^-\ell^+\ell^-$, $\ell^+\ell^-q\bar{q}$, and $\ell^+\ell^-\nu\bar{\nu}$ in 35.9 fb^{-1} of pp collisions at $E_{\text{cm}} = 13$ TeV. See their Figs. 10 and 11 for upper limits on cross section times branching ratio for $m_{H_2^0} = 0.13\text{--}3$ TeV with several assumptions on its width and on the fraction of Vector-Boson-Fusion of the total production cross section.
- 135 SIRUNYAN 18CW search for a narrow scalar resonance decaying to $HH \rightarrow b\bar{b}b\bar{b}$ in 35.9 fb^{-1} of pp collisions at $E_{\text{cm}} = 13$ TeV, where both $b\bar{b}$ pairs are resolved. See their Fig. 9 for limits on cross section times branching ratios for $m_{H_2^0} = 260\text{--}1200$ GeV.
- 136 SIRUNYAN 18DK search for production of a scalar resonance decaying to $Z\gamma$, with Z decaying to $\ell^+\ell^-$ or hadronically, 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 ratio for $m_{H_2^0} = 0.35\text{--}4$ TeV for different assumptions on the width of the resonance.
- 137 SIRUNYAN 18DT search for the decay $H \rightarrow A^0 A^0 \rightarrow \tau^+\tau^- b\bar{b}$ in 35.9 fb^{-1} of pp collisions at $E_{\text{cm}} = 13$ TeV. See their Fig. 7 for limits on the product of branching ratios in the range $m_{A^0} = 15\text{--}60$ GeV. See also their Fig. 8 for interpretation of the data in terms of models with two Higgs doublets and a singlet.

- 138 SIRUNYAN 18DU search for production of a narrow scalar resonance decaying to $\gamma\gamma$ in 35.9 fb^{-1} (taken in 2016) of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$. See their Fig. 3 (right) for limits on cross section times branching ratio for $m_{H_2^0} = 0.5\text{--}5 \text{ TeV}$ for several values of its width-to-mass ratio.
- 139 SIRUNYAN 18ED search for production of an A^0 in gluon-gluon fusion and in association with a $b\bar{b}$, decaying to ZH in the final states $\nu\bar{\nu}b\bar{b}$ or $\ell^+\ell^-b\bar{b}$ in 35.9 fb^{-1} of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$. See their Fig. 8 for cross section limits for $m_{A^0} = 0.8\text{--}2 \text{ TeV}$.
- 140 SIRUNYAN 18EE search for the decay $H \rightarrow A^0 A^0 \rightarrow \mu^+\mu^-\tau^+\tau^-$ in 35.9 fb^{-1} of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$. See their Fig. 4 for limits on the product of branching ratios in the range $m_{A^0} = 15\text{--}62.5 \text{ GeV}$, normalized to the SM production cross section. See also their Fig. 5 for interpretation of the data in terms of models with two Higgs doublets and a singlet.
- 141 SIRUNYAN 18F search for a narrow scalar resonance decaying to $HH \rightarrow WWb\bar{b}$ or $ZZb\bar{b}$ in the final state $\ell\ell\nu\nu b\bar{b}$ in 35.9 fb^{-1} of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$. See their Fig. 7 for limits on cross section times branching ratios for $m_{H_2^0} = 250\text{--}900 \text{ GeV}$.
- 142 AABOUD 17 search for production of a scalar resonance decaying to $Z\gamma$ in 3.2 fb^{-1} of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$. See their Fig. 4 for the limits on cross section times branching ratio for $m_{H_2^0} = 0.25\text{--}3.0 \text{ TeV}$.
- 143 AABOUD 17AP search for production of a scalar resonance decaying to $\gamma\gamma$ in 36.7 fb^{-1} of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$. See their Fig. 4(a) for limits on fiducial cross section times branching ratio for $m_{H_2^0} = 0.2\text{--}2.7 \text{ TeV}$ with narrow width approximation.
- 144 AABOUD 17AW search for production of a scalar resonance decaying to $Z\gamma$ in 36.1 fb^{-1} of pp collisions at $E_{\text{cm}} = 13 \text{ TeV}$. See their Fig. 7 for limits on cross section times branching ratio for $m_{H_2^0} = 0.25\text{--}2.4 \text{ TeV}$.
- 145 KHACHATRYAN 17AZ search for the decay $H \rightarrow A^0 A^0 \rightarrow \tau^+\tau^-\tau^+\tau^-$, $\mu^+\mu^-b\bar{b}$, 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.
- 146 KHACHATRYAN 17D search for production of a scalar resonance decaying to $Z\gamma$ in 19.7 fb^{-1} of pp collisions at $E_{\text{cm}} = 8 \text{ TeV}$ and 2.7 fb^{-1} at $E_{\text{cm}} = 13 \text{ TeV}$. See their Figs. 3 and 4 for the limits on cross section times branching ratio for $m_{H_2^0} = 0.2\text{--}2.0 \text{ TeV}$.
- 147 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 $E_{\text{cm}} = 13 \text{ TeV}$. See their Fig. 2 for limits on cross section times branching ratio for $m_{H_2^0} = 0.5\text{--}4.5 \text{ TeV}$ for several values of its width-to-mass ratio. Limits from combination with KHACHATRYAN 16M are shown in their Figs. 4 and 6.
- 148 SIRUNYAN 17CN search for a narrow scalar resonance decaying to $HH \rightarrow b\bar{b}\tau^+\tau^-$ 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.
- 149 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.

- 150 AABOUD 16AB search for associated production of WH with the decay $H \rightarrow A^0 A^0 \rightarrow b\bar{b}b\bar{b}$ 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 $m_{A^0} = 20\text{--}60 \text{ GeV}$.
- 151 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 $m_{H_2^0} = 0.5\text{--}3 \text{ TeV}$.
- 152 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.
- 153 AABOUD 16I search for a narrow scalar resonance decaying to $HH \rightarrow b\bar{b}b\bar{b}$ 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 $m_{H_2^0} = 0.5\text{--}3 \text{ TeV}$.
- 154 AAD 16AX search for production of a heavy H 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 $\sigma(H) \text{B}(H \rightarrow ZZ)$ for m_H ranging from 140 GeV to 1000 GeV.
- 155 AAD 16C search for production of a heavy H 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 $\sigma(H) \text{B}(H \rightarrow W^+W^-)$ for m_H ranging from 300 GeV to 1000 or 1500 GeV with various assumptions on the total width of H .
- 156 AAD 16L search for the decay $H \rightarrow A^0 A^0 \rightarrow \gamma\gamma\gamma\gamma$ 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 cross section) for $m_{A^0} = 10\text{--}60 \text{ GeV}$.
- 157 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 .
- 158 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.
- 159 KHACHATRYAN 16BG search for a narrow scalar resonance decaying to $HH \rightarrow b\bar{b}b\bar{b}$ 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 $m_{H_2^0} = 1.15\text{--}3 \text{ TeV}$.
- 160 KHACHATRYAN 16BQ search for a resonance decaying to $HH \rightarrow \gamma\gamma b\bar{b}$ 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 $m_{H_2^0} = 0.26\text{--}1.1 \text{ TeV}$.
- 161 KHACHATRYAN 16F search for the decay $H \rightarrow H_1^0 H_1^0 \rightarrow \tau^+\tau^-\tau^+\tau^-$ in 19.7 fb^{-1} of pp collisions at $E_{\text{cm}} = 8 \text{ TeV}$. See their Fig. 8 for cross section limits for $m_{H_1^0} = 4\text{--}8 \text{ GeV}$.
- 162 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 $m_{H_2^0} = 0.5\text{--}4 \text{ TeV}$.
- 163 KHACHATRYAN 16P search for gluon fusion production of an H_2^0 decaying to $HH \rightarrow b\bar{b}\tau^+\tau^-$ 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 $m_{H_2^0} = 260\text{--}350 \text{ GeV}$.

- 164 KHACHATRYAN 16P search for gluon fusion production of an A^0 decaying to $ZH \rightarrow \ell^+ \ell^- \tau^+ \tau^-$ in 19.7 fb^{-1} of pp collisions at $E_{\text{cm}} = 8 \text{ TeV}$. See their Fig. 10 for cross section limits for $m_{H_2^0} = 220\text{--}350 \text{ GeV}$.
- 165 AAD 15BK search for production of a heavy H_2^0 decaying to HH 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 $\sigma(H_2^0) \text{B}(H_2^0 \rightarrow HH)$ for $m_{H_2^0} = 500\text{--}1500 \text{ GeV}$ with $\Gamma_{H_2^0} = 1 \text{ GeV}$.
- 166 AAD 15BZ search for the decay $H \rightarrow A^0 A^0 \rightarrow \mu^+ \mu^- \tau^+ \tau^-$ ($m_H = 125 \text{ GeV}$) 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 $m_{A^0} = 3.7\text{--}50 \text{ GeV}$.
- 167 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 $m_{A^0} = 5 \text{ GeV}$.
- 168 AAD 15CE search for production of a heavy H_2^0 decaying to HH 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 $\sigma(H_2^0) \text{B}(H_2^0 \rightarrow HH) < 2.1\text{--}0.011 \text{ pb}$ (95% CL) is given for $m_{H_2^0} = 260\text{--}1000 \text{ GeV}$. See their Fig. 6.
- 169 AAD 15H search for production of a heavy H_2^0 decaying to HH 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 $\sigma(H_2^0) \text{B}(H_2^0 \rightarrow HH) < 3.5\text{--}0.7 \text{ pb}$ is given for $m_{H_2^0} = 260\text{--}500 \text{ GeV}$ at 95% CL. See their Fig. 3.
- 170 AAD 15S search for production of A^0 decaying to $ZH \rightarrow \ell^+ \ell^- b\bar{b}$, $\nu\bar{\nu}b\bar{b}$ 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 $m_{A^0} = 200\text{--}1000 \text{ GeV}$.
- 171 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.
- 172 KHACHATRYAN 15BB search for production of a resonance H 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 $m_H = 150\text{--}850 \text{ GeV}$.
- 173 KHACHATRYAN 15N search for production of A^0 decaying to $ZH \rightarrow \ell^+ \ell^- b\bar{b}$ 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 $m_{A^0} = 225\text{--}600 \text{ GeV}$.
- 174 KHACHATRYAN 15O search for production of a high-mass narrow resonance A^0 decaying to $ZH \rightarrow q\bar{q}\tau^+\tau^-$ 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 $m_{A^0} = 800\text{--}2500 \text{ GeV}$.
- 175 KHACHATRYAN 15R search for a narrow scalar resonance decaying to $HH \rightarrow b\bar{b}b\bar{b}$ 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 $m_{H_2^0} = 0.27\text{--}1.1 \text{ TeV}$.
- 176 AAD 14AP search for a second H 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 $m_H = 65\text{--}600 \text{ GeV}$.

- 177 AAD 14M search for the decay cascade $H_2^0 \rightarrow H^\pm W^\mp \rightarrow HW^\pm W^\mp$, H 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 $m_{H_2^0} = 325\text{--}1025 \text{ GeV}$ and $m_{H^\pm} = 225\text{--}925 \text{ GeV}$.
- 178 CHATRCHYAN 14G search for a second H 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 $110\text{--}600 \text{ GeV}$.
- 179 KHACHATRYAN 14P search for a second H 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 $110\text{--}150 \text{ GeV}$.
- 180 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 via the decay chain $H'^0 \rightarrow H^\pm W^\mp$, $H^\pm \rightarrow W^\pm H$, $H \rightarrow b\bar{b}$ 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 $m_H = 126 \text{ GeV}$.
- 181 CHATRCHYAN 13BJ search for H production in the decay chain $H \rightarrow A^0 A^0$, $A^0 \rightarrow \mu^+ \mu^-$ 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.
- 182 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 $90 < m_{H^+} < 160 \text{ GeV}$.
- 183 ABBIENDI 10 search for $e^+ e^- \rightarrow ZH$ with the decay chain $H \rightarrow \tilde{\chi}_1^0 \tilde{\chi}_2^0$, $\tilde{\chi}_2^0 \rightarrow \tilde{\chi}_1^0 + (\gamma \text{ or } Z^*)$, 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 of 108.4 (107.0) GeV (95% CL) is obtained for SM ZH cross section and $B(H \rightarrow \tilde{\chi}_1^0 \tilde{\chi}_2^0) = 1$.
- 184 SCHAEEL 10 search for the process $e^+ e^- \rightarrow HZ$ followed by the decay chain $H \rightarrow A^0 A^0 \rightarrow \tau^+ \tau^- \tau^+ \tau^-$ with $Z \rightarrow \ell^+ \ell^-$, $\nu\bar{\nu}$ at $E_{\text{cm}} = 183\text{--}209 \text{ GeV}$. For a HZZ coupling equal to the SM value, $B(H \rightarrow A^0 A^0) = B(A^0 \rightarrow \tau^+ \tau^-) = 1$, and $m_{A^0} = 4\text{--}10 \text{ GeV}$, m_H up to 107 GeV is excluded at 95% CL.
- 185 ABAZOV 09V search for H production followed by the decay chain $H \rightarrow A^0 A^0 \rightarrow \mu^+ \mu^- \mu^+ \mu^-$ 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 $\sigma(H) \cdot B(H \rightarrow A^0 A^0)$ for $m_{A^0} = 3.6\text{--}19 \text{ GeV}$.
- 186 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 $H_1^0 \rightarrow A^0 A^0$.
- 187 ABBIENDI 04K search for $e^+ e^- \rightarrow HZ$ with H decaying to two jets of any flavor including gg . The limit is for SM production cross section with $B(H \rightarrow jj) = 1$.
- 188 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.
- 189 ACHARD 04B search for $e^+ e^- \rightarrow HZ$ with H decaying to $b\bar{b}$, $c\bar{c}$, or gg . The limit is for SM production cross section with $B(H \rightarrow jj) = 1$.
- 190 ACHARD 04F search for H with anomalous coupling to gauge boson pairs in the processes $e^+ e^- \rightarrow H\gamma$, $e^+ e^- H$, HZ with decays $H \rightarrow f\bar{f}$, $\gamma\gamma$, $Z\gamma$, and $W^* W$ at $E_{\text{cm}} = 189\text{--}209 \text{ GeV}$. See paper for limits.
- 191 ABBIENDI 03F search for $H \rightarrow$ anything in $e^+ e^- \rightarrow HZ$, using the recoil mass spectrum of $Z \rightarrow e^+ e^-$ or $\mu^+ \mu^-$. In addition, it searched for $Z \rightarrow \nu\bar{\nu}$ and $H \rightarrow e^+ e^-$ or photons. Scenarios with large width or continuum H mass distribution are considered. See their Figs. 11–14 for the results.

- 192 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.
- 193 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 with SM production cross section and $B(H \rightarrow f\bar{f})=0$ for all fermions f .
- 194 For $B(H \rightarrow \gamma\gamma)=1$, $m_H > 113.1$ GeV is obtained.
- 195 HEISTER 02M search for $e^+e^- \rightarrow HZ$, assuming that H decays to $q\bar{q}$, gg , or $\tau^+\tau^-$ only. The limit assumes SM production cross section.
- 196 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.
- 197 ACCIARRI 00R search for $e^+e^- \rightarrow H\gamma$ with $H \rightarrow b\bar{b}$, $Z\gamma$, 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.
- 198 ACCIARRI 00R search for the two-photon type processes $e^+e^- \rightarrow e^+e^-H$ with $H \rightarrow b\bar{b}$ or $\gamma\gamma$. See their Fig. 4 for limits on $\Gamma(H \rightarrow \gamma\gamma) \cdot B(H \rightarrow \gamma\gamma \text{ or } b\bar{b})$ for $m_H=70\text{--}170$ GeV.
- 199 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.
- 200 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.
- 201 ALEXANDER 96H give $B(Z \rightarrow H\gamma) \times B(H \rightarrow q\bar{q}) < 1\text{--}4 \times 10^{-5}$ (95%CL) and $B(Z \rightarrow H\gamma) \times B(H \rightarrow b\bar{b}) < 0.7\text{--}2 \times 10^{-5}$ (95%CL) in the range $20 < m_H < 80$ GeV.

Electroweak Constraints on the Standard Model Higgs Boson Mass

Here we list constraints on the mass of the Higgs boson derived from fits to precision electroweak observables, assuming the minimal Standard Model with a doublet Higgs field and three generations of fermions.

<u>VALUE (GeV)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>
90⁺²¹₋₁₈	¹ HALLER 18	RVUE
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●		
91 ⁺³⁰ ₋₂₃	² BAAK 12	RVUE
94 ⁺²⁵ ₋₂₂	³ BAAK 12A	RVUE
91 ⁺³¹ ₋₂₄	⁴ ERLER 10A	RVUE
129 ⁺⁷⁴ ₋₄₉	⁵ LEP-SLC 06	RVUE

¹ HALLER 18 make Standard Model fits to Z and neutral current parameters, m_t , m_W , and Γ_W measurements available in 2018. The direct mass measurement at the LHC is not used in the fit.

- 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_{-5}^{+12} GeV.
- ³ 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.
- ⁴ 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.
- ⁵ 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.

SEARCHES FOR NEUTRAL HIGGS BOSONS REFERENCES

AAD	25AL	EPJ C85 573	G. Aad <i>et al.</i>	(ATLAS Collab.)
AAD	25AN	EPJ C85 886	G. Aad <i>et al.</i>	(ATLAS Collab.)
AAD	25AT	PL B868 139671	G. Aad <i>et al.</i>	(ATLAS Collab.)
AAD	25AU	PL B870 139843	G. Aad <i>et al.</i>	(ATLAS Collab.)
AAD	25AW	PR D112 072005	G. Aad <i>et al.</i>	(ATLAS Collab.)
AAD	25AY	PR D112 092001	G. Aad <i>et al.</i>	(ATLAS Collab.)
AAD	25F	PL B865 139472	G. Aad <i>et al.</i>	(ATLAS Collab.)
AAD	25J	PR D111 032006	G. Aad <i>et al.</i>	(ATLAS Collab.)
AAD	25O	JHEP 2501 053	G. Aad <i>et al.</i>	(ATLAS Collab.)
AAD	25X	JHEP 2503 190	G. Aad <i>et al.</i>	(ATLAS Collab.)
ADAN	25	JHEP 2509 096	D.P. Adan	(AACHI)
CHEKHOVSKY	25C	JHEP 2506 144	V. Chekhovskiy <i>et al.</i>	(CMS Collab.)
CHEKHOVSKY	25D	JHEP 2508 085	V. Chekhovskiy <i>et al.</i>	(CMS Collab.)
CHEKHOVSKY	25I	JHEP 2510 074	V. Chekhovskiy <i>et al.</i>	(CMS Collab.)
CHEKHOVSKY	25J	JHEP 2510 170	V. Chekhovskiy <i>et al.</i>	(CMS Collab.)
CORTINA-GIL	25B	JHEP 2511 143	E. Cortina Gil <i>et al.</i>	(NA62 Collab.)
HAYRAPETYAN...	25A	PL B860 139067	A. Hayrapetyan <i>et al.</i>	(CMS Collab.)
HAYRAPETYAN...	25AP	JHEP 2512 178	A. Hayrapetyan <i>et al.</i>	(CMS Collab.)
HAYRAPETYAN...	25C	PRL 134 041801	A. Hayrapetyan <i>et al.</i>	(CMS Collab.)
HAYRAPETYAN...	25I	PL B866 139568	A. Hayrapetyan <i>et al.</i>	(CMS Collab.)
HAYRAPETYAN...	25P	JHEP 2502 050	A. Hayrapetyan <i>et al.</i>	(CMS Collab.)
AAD	24A	PL B848 138394	G. Aad <i>et al.</i>	(ATLAS Collab.)
AAD	24AB	JHEP 2402 197	G. Aad <i>et al.</i>	(ATLAS Collab.)
AAD	24AP	JHEP 2408 013	G. Aad <i>et al.</i>	(ATLAS Collab.)
AAD	24BQ	PR D110 052013	G. Aad <i>et al.</i>	(ATLAS Collab.)
AAD	24BV	PL B858 139007	G. Aad <i>et al.</i>	(ATLAS Collab.)
AAD	24BW	JHEP 2410 104	G. Aad <i>et al.</i>	(ATLAS Collab.)
AAD	24BX	JHEP 2410 130	G. Aad <i>et al.</i>	(ATLAS Collab.)
AAD	24CA	JHEP 2411 047	G. Aad <i>et al.</i>	(ATLAS Collab.)
AAD	24CB	JHEP 2411 097	G. Aad <i>et al.</i>	(ATLAS Collab.)
AAD	24CD	JHEP 2411 126	G. Aad <i>et al.</i>	(ATLAS Collab.)
AAD	24CF	JHEP 2412 126	G. Aad <i>et al.</i>	(ATLAS Collab.)
AAD	24CI	EPJ C84 1102	G. Aad <i>et al.</i>	(ATLAS Collab.)
AAD	24CK	SCIB 69 3005	G. Aad <i>et al.</i>	(ATLAS Collab.)
AAD	24H	PRL 132 231801	G. Aad <i>et al.</i>	(ATLAS Collab.)
AAD	24K	PL B850 138536	G. Aad <i>et al.</i>	(ATLAS Collab.)
ADACHI	24F	PR D109 112015	I. Adachi <i>et al.</i>	(BELLE II Collab.)
HAYRAPETYAN...	24AA	JHEP 2406 097	A. Hayrapetyan <i>et al.</i>	(CMS Collab.)
HAYRAPETYAN...	24AE	JHEP 2407 293	A. Hayrapetyan <i>et al.</i>	(CMS Collab.)
HAYRAPETYAN...	24AF	EPJ C84 493	A. Hayrapetyan <i>et al.</i>	(CMS Collab.)
HAYRAPETYAN...	24AI	PR D110 032007	A. Hayrapetyan <i>et al.</i>	(CMS Collab.)
HAYRAPETYAN...	24AJ	JHEP 2408 215	A. Hayrapetyan <i>et al.</i>	(CMS Collab.)
HAYRAPETYAN...	24AZ	JHEP 2412 172	A. Hayrapetyan <i>et al.</i>	(CMS Collab.)
HAYRAPETYAN...	24H	PL B850 138478	A. Hayrapetyan <i>et al.</i>	(CMS Collab.)
HAYRAPETYAN...	24I	PL B852 138582	A. Hayrapetyan <i>et al.</i>	(CMS Collab.)

TUMASYAN	24A	PR D110 012013	A. Tumasyan <i>et al.</i>	(CMS Collab.)
TUMASYAN	24B	JHEP 2405 316	A. Tumasyan <i>et al.</i>	(CMS Collab.)
AAD	23AD	EPJ C83 519	G. Aad <i>et al.</i>	(ATLAS Collab.)
AAD	23AJ	EPJ C83 603	G. Aad <i>et al.</i>	(ATLAS Collab.)
AAD	23BD	JHEP 2307 199	G. Aad <i>et al.</i>	(ATLAS Collab.)
AAD	23BE	JHEP 2307 200	G. Aad <i>et al.</i>	(ATLAS Collab.)
AAD	23BG	JHEP 2307 203	G. Aad <i>et al.</i>	(ATLAS Collab.)
Also		JHEP 2505 159 (errat.)	G. Aad <i>et al.</i>	(ATLAS Collab.)
AAD	23BW	PR D108 092007	G. Aad <i>et al.</i>	(ATLAS Collab.)
AAD	23BX	JHEP 2309 189	G. Aad <i>et al.</i>	(ATLAS Collab.)
AAD	23CA	JHEP 2310 009	G. Aad <i>et al.</i>	(ATLAS Collab.)
AAD	23CR	JHEP 2312 081	G. Aad <i>et al.</i>	(ATLAS Collab.)
AAD	23O	JHEP 2306 016	G. Aad <i>et al.</i>	(ATLAS Collab.)
AAD	23R	JHEP 2307 155	G. Aad <i>et al.</i>	(ATLAS Collab.)
AAD	23U	JHEP 2307 125	G. Aad <i>et al.</i>	(ATLAS Collab.)
AAD	23Z	JHEP 2307 040	G. Aad <i>et al.</i>	(ATLAS Collab.)
ADACHI	23A	PRL 130 181803	I. Adachi <i>et al.</i>	(BELLE II Collab.)
HAYRAPETY...	23C	PR D108 072004	A. Hayrapetyan <i>et al.</i>	(CMS Collab.)
HAYRAPETY...	23G	JHEP 2312 070	A. Hayrapetyan <i>et al.</i>	(CMS Collab.)
TUMASYAN	23	PL B842 137392	A. Tumasyan <i>et al.</i>	(CMS Collab.)
TUMASYAN	23AR	PRL 131 101801	A. Tumasyan <i>et al.</i>	(CMS Collab.)
TUMASYAN	23M	JHEP 2307 148	A. Tumasyan <i>et al.</i>	(CMS Collab.)
TUMASYAN	23O	JHEP 2307 095	A. Tumasyan <i>et al.</i>	(CMS Collab.)
TUMASYAN	23S	JHEP 2307 073	A. Tumasyan <i>et al.</i>	(CMS Collab.)
AAD	22A	PR D105 012006	G. Aad <i>et al.</i>	(ATLAS Collab.)
AAD	22D	PL B829 137066	G. Aad <i>et al.</i>	(ATLAS Collab.)
AAD	22F	PR D105 092002	G. Aad <i>et al.</i>	(ATLAS Collab.)
AAD	22I	JHEP 2201 063	G. Aad <i>et al.</i>	(ATLAS Collab.)
AAD	22J	JHEP 2203 041	G. Aad <i>et al.</i>	(ATLAS Collab.)
AAD	22P	JHEP 2208 104	G. Aad <i>et al.</i>	(ATLAS Collab.)
AAD	22Y	PR D106 052001	G. Aad <i>et al.</i>	(ATLAS Collab.)
ABLIKIM	22H	PR D105 012008	M. Ablikim <i>et al.</i>	(BESIII Collab.)
ABRATENKO	22A	PR D106 092006	P. Abratenko <i>et al.</i>	(MicroBooNE Collab.)
JIA	22	PRL 128 081804	S. Jia <i>et al.</i>	(BELLE Collab.)
TUMASYAN	22AK	PL B835 137566	A. Tumasyan <i>et al.</i>	(CMS Collab.)
TUMASYAN	22D	PR D105 032008	A. Tumasyan <i>et al.</i>	(CMS Collab.)
AAD	21AF	EPJ C81 332	G. Aad <i>et al.</i>	(ATLAS Collab.)
AAD	21AI	EPJ C81 396	G. Aad <i>et al.</i>	(ATLAS Collab.)
AAD	21AY	PL B822 136651	G. Aad <i>et al.</i>	(ATLAS Collab.)
AAD	21AZ	JHEP 2110 013	G. Aad <i>et al.</i>	(ATLAS Collab.)
AAD	21BB	JHEP 2111 209	G. Aad <i>et al.</i>	(ATLAS Collab.)
AAD	21BE	EPJ C81 860	G. Aad <i>et al.</i>	(ATLAS Collab.)
ABRATENKO	21	PRL 127 151803	P. Abratenko <i>et al.</i>	(MicroBooNE Collab.)
SIRUNYAN	21A	EPJ C81 13	A.M. Sirunyan <i>et al.</i>	(CMS Collab.)
Also		EPJ C81 333 (errat.)	A.M. Sirunyan <i>et al.</i>	(CMS Collab.)
SLAVICH	21	EPJ C81 450	P. Slavich <i>et al.</i>	
TUMASYAN	21F	JHEP 2111 057	A. Tumasyan <i>et al.</i>	(CMS Collab.)
AAD	20	PR D101 012002	G. Aad <i>et al.</i>	(ATLAS Collab.)
AAD	20AA	PRL 125 051801	G. Aad <i>et al.</i>	(ATLAS Collab.)
AAD	20AE	PRL 125 221802	G. Aad <i>et al.</i>	(ATLAS Collab.)
AAD	20AI	PR D102 112006	G. Aad <i>et al.</i>	(ATLAS Collab.)
AAD	20AO	JHEP 2011 163	G. Aad <i>et al.</i>	(ATLAS Collab.)
AAD	20C	PL B800 135103	G. Aad <i>et al.</i>	(ATLAS Collab.)
AAD	20L	PR D102 032004	G. Aad <i>et al.</i>	(ATLAS Collab.)
AAD	20X	JHEP 2007 108	G. Aad <i>et al.</i>	(ATLAS Collab.)
Also		JHEP 2101 145 (errat.)	G. Aad <i>et al.</i>	(ATLAS Collab.)
Also		JHEP 2105 207 (errat.)	G. Aad <i>et al.</i>	(ATLAS Collab.)
AAIJ	20AL	JHEP 2010 156	R. Aaij <i>et al.</i>	(LHCb Collab.)
SIRUNYAN	20	PL B800 135087	A.M. Sirunyan <i>et al.</i>	(CMS Collab.)
SIRUNYAN	20AA	JHEP 2003 055	A.M. Sirunyan <i>et al.</i>	(CMS Collab.)
SIRUNYAN	20AC	JHEP 2003 065	A.M. Sirunyan <i>et al.</i>	(CMS Collab.)
SIRUNYAN	20AD	JHEP 2003 103	A.M. Sirunyan <i>et al.</i>	(CMS Collab.)
SIRUNYAN	20AF	JHEP 2004 171	A.M. Sirunyan <i>et al.</i>	(CMS Collab.)
SIRUNYAN	20AP	JHEP 2008 139	A.M. Sirunyan <i>et al.</i>	(CMS Collab.)
SIRUNYAN	20Y	JHEP 2003 034	A.M. Sirunyan <i>et al.</i>	(CMS Collab.)
SIRUNYAN	20Z	JHEP 2003 051	A.M. Sirunyan <i>et al.</i>	(CMS Collab.)
AABOUD	19A	JHEP 1901 030	M. Aaboud <i>et al.</i>	(ATLAS Collab.)
AABOUD	19AG	PL B790 1	M. Aaboud <i>et al.</i>	(ATLAS Collab.)
AABOUD	19AI	PL B793 499	M. Aaboud <i>et al.</i>	(ATLAS Collab.)
AABOUD	19O	JHEP 1904 092	M. Aaboud <i>et al.</i>	(ATLAS Collab.)
AABOUD	19T	JHEP 1905 124	M. Aaboud <i>et al.</i>	(ATLAS Collab.)

AABOUD	19V	JHEP 1905 142	M. Aaboud <i>et al.</i>	(ATLAS Collab.)
AABOUD	19Y	JHEP 1907 117	M. Aaboud <i>et al.</i>	(ATLAS Collab.)
AALTONEN	19	PR D99 052001	T. Aaltonen <i>et al.</i>	(CDF Collab.)
BAGNASCHI	19	EPJ C79 617	E. Bagnaschi <i>et al.</i>	
SIRUNYAN	19	PL B788 7	A.M. Sirunyan <i>et al.</i>	(CMS Collab.)
SIRUNYAN	19AE	JHEP 1905 210	A.M. Sirunyan <i>et al.</i>	(CMS Collab.)
SIRUNYAN	19AN	EPJ C79 280	A.M. Sirunyan <i>et al.</i>	(CMS Collab.)
SIRUNYAN	19AV	EPJ C79 564	A.M. Sirunyan <i>et al.</i>	(CMS Collab.)
SIRUNYAN	19B	PR D99 012005	A.M. Sirunyan <i>et al.</i>	(CMS Collab.)
SIRUNYAN	19BB	PL B793 320	A.M. Sirunyan <i>et al.</i>	(CMS Collab.)
SIRUNYAN	19BD	PL B795 398	A.M. Sirunyan <i>et al.</i>	(CMS Collab.)
SIRUNYAN	19BE	PRL 122 121803	A.M. Sirunyan <i>et al.</i>	(CMS Collab.)
SIRUNYAN	19BQ	PL B796 131	A.M. Sirunyan <i>et al.</i>	(CMS Collab.)
SIRUNYAN	19CR	PL B798 134992	A.M. Sirunyan <i>et al.</i>	(CMS Collab.)
SIRUNYAN	19H	JHEP 1901 040	A.M. Sirunyan <i>et al.</i>	(CMS Collab.)
AABOUD	18AA	PR D98 032015	M. Aaboud <i>et al.</i>	(ATLAS Collab.)
AABOUD	18AG	PL B782 750	M. Aaboud <i>et al.</i>	(ATLAS Collab.)
AABOUD	18AH	PL B783 392	M. Aaboud <i>et al.</i>	(ATLAS Collab.)
AABOUD	18AI	JHEP 1803 174	M. Aaboud <i>et al.</i>	(ATLAS Collab.)
Also		JHEP 1811 051 (errat.)	M. Aaboud <i>et al.</i>	(ATLAS Collab.)
AABOUD	18AP	JHEP 1806 166	M. Aaboud <i>et al.</i>	(ATLAS Collab.)
AABOUD	18BF	EPJ C78 293	M. Aaboud <i>et al.</i>	(ATLAS Collab.)
AABOUD	18BU	EPJ C78 1007	M. Aaboud <i>et al.</i>	(ATLAS Collab.)
AABOUD	18BX	JHEP 1810 031	M. Aaboud <i>et al.</i>	(ATLAS Collab.)
AABOUD	18CC	JHEP 1811 051 (errat.)	M. Aaboud <i>et al.</i>	(ATLAS Collab.)
AABOUD	18CE	JHEP 1812 039	M. Aaboud <i>et al.</i>	(ATLAS Collab.)
AABOUD	18CQ	PRL 121 191801	M. Aaboud <i>et al.</i>	(ATLAS Collab.)
AABOUD	18CW	JHEP 1811 040	M. Aaboud <i>et al.</i>	(ATLAS Collab.)
AABOUD	18F	PL B777 91	M. Aaboud <i>et al.</i>	(ATLAS Collab.)
AABOUD	18G	JHEP 1801 055	M. Aaboud <i>et al.</i>	(ATLAS Collab.)
AAIJ	18AM	EPJ C78 1008	R. Aaij <i>et al.</i>	(LHCb Collab.)
AAIJ	18AQ	JHEP 1809 147	R. Aaij <i>et al.</i>	(LHCb Collab.)
HALLER	18	EPJ C78 675	J. Haller <i>et al.</i>	(Gfitter Group)
SIRUNYAN	18A	PL B778 101	A.M. Sirunyan <i>et al.</i>	(CMS Collab.)
SIRUNYAN	18AF	PL B781 244	A.M. Sirunyan <i>et al.</i>	(CMS Collab.)
SIRUNYAN	18BA	JHEP 1806 127	A.M. Sirunyan <i>et al.</i>	(CMS Collab.)
Also		JHEP 1903 128 (errat.)	A.M. Sirunyan <i>et al.</i>	(CMS Collab.)
SIRUNYAN	18BP	JHEP 1808 113	A.M. Sirunyan <i>et al.</i>	(CMS Collab.)
SIRUNYAN	18CW	JHEP 1808 152	A.M. Sirunyan <i>et al.</i>	(CMS Collab.)
SIRUNYAN	18CX	JHEP 1809 007	A.M. Sirunyan <i>et al.</i>	(CMS Collab.)
SIRUNYAN	18DK	JHEP 1809 148	A.M. Sirunyan <i>et al.</i>	(CMS Collab.)
SIRUNYAN	18DT	PL B785 462	A.M. Sirunyan <i>et al.</i>	(CMS Collab.)
SIRUNYAN	18DU	PR D98 092001	A.M. Sirunyan <i>et al.</i>	(CMS Collab.)
SIRUNYAN	18ED	JHEP 1811 172	A.M. Sirunyan <i>et al.</i>	(CMS Collab.)
SIRUNYAN	18EE	JHEP 1811 018	A.M. Sirunyan <i>et al.</i>	(CMS Collab.)
SIRUNYAN	18F	JHEP 1801 054	A.M. Sirunyan <i>et al.</i>	(CMS Collab.)
AABOUD	17	PL B764 11	M. Aaboud <i>et al.</i>	(ATLAS Collab.)
AABOUD	17AN	PRL 119 191803	M. Aaboud <i>et al.</i>	(ATLAS Collab.)
AABOUD	17AP	PL B775 105	M. Aaboud <i>et al.</i>	(ATLAS Collab.)
AABOUD	17AW	JHEP 1710 112	M. Aaboud <i>et al.</i>	(ATLAS Collab.)
KHACHATRY...	17AZ	JHEP 1710 076	V. Khachatryan <i>et al.</i>	(CMS Collab.)
KHACHATRY...	17D	JHEP 1701 076	V. Khachatryan <i>et al.</i>	(CMS Collab.)
KHACHATRY...	17R	PL B767 147	V. Khachatryan <i>et al.</i>	(CMS Collab.)
SIRUNYAN	17AX	JHEP 1711 010	A.M. Sirunyan <i>et al.</i>	(CMS Collab.)
SIRUNYAN	17CN	PR D96 072004	A.M. Sirunyan <i>et al.</i>	(CMS Collab.)
SIRUNYAN	17Y	PL B772 363	A.M. Sirunyan <i>et al.</i>	(CMS Collab.)
AABOUD	16AA	EPJ C76 585	M. Aaboud <i>et al.</i>	(ATLAS Collab.)
AABOUD	16AB	EPJ C76 605	M. Aaboud <i>et al.</i>	(ATLAS Collab.)
AABOUD	16AE	JHEP 1609 173	M. Aaboud <i>et al.</i>	(ATLAS Collab.)
AABOUD	16H	JHEP 1609 001	M. Aaboud <i>et al.</i>	(ATLAS Collab.)
AABOUD	16I	PR D94 052002	M. Aaboud <i>et al.</i>	(ATLAS Collab.)
AAD	16AX	EPJ C76 45	G. Aad <i>et al.</i>	(ATLAS Collab.)
AAD	16C	JHEP 1601 032	G. Aad <i>et al.</i>	(ATLAS Collab.)
AAD	16L	EPJ C76 210	G. Aad <i>et al.</i>	(ATLAS Collab.)
AALTONEN	16C	PR D93 112010	T. Aaltonen <i>et al.</i>	(CDF Collab.)
ABLIKIM	16E	PR D93 052005	M. Ablikim <i>et al.</i>	(BESIII Collab.)
KHACHATRY...	16A	PL B752 221	V. Khachatryan <i>et al.</i>	(CMS Collab.)
KHACHATRY...	16BG	EPJ C76 371	V. Khachatryan <i>et al.</i>	(CMS Collab.)
KHACHATRY...	16BQ	PR D94 052012	V. Khachatryan <i>et al.</i>	(CMS Collab.)
KHACHATRY...	16F	JHEP 1601 079	V. Khachatryan <i>et al.</i>	(CMS Collab.)
KHACHATRY...	16M	PRL 117 051802	V. Khachatryan <i>et al.</i>	(CMS Collab.)

KHACHATRY...	16P	PL B755 217	V. Khachatryan <i>et al.</i>	(CMS Collab.)
KHACHATRY...	16W	PL B758 296	V. Khachatryan <i>et al.</i>	(CMS Collab.)
KHACHATRY...	16Z	PL B759 369	V. Khachatryan <i>et al.</i>	(CMS Collab.)
AAD	15BD	EPJ C75 337	G. Aad <i>et al.</i>	(ATLAS Collab.)
AAD	15BH	EPJ C75 299	G. Aad <i>et al.</i>	(ATLAS Collab.)
Also		EPJ C75 408 (errat.)	G. Aad <i>et al.</i>	(ATLAS Collab.)
AAD	15BK	EPJ C75 412	G. Aad <i>et al.</i>	(ATLAS Collab.)
AAD	15BZ	PR D92 052002	G. Aad <i>et al.</i>	(ATLAS Collab.)
AAD	15CE	PR D92 092004	G. Aad <i>et al.</i>	(ATLAS Collab.)
AAD	15H	PRL 114 081802	G. Aad <i>et al.</i>	(ATLAS Collab.)
AAD	15S	PL B744 163	G. Aad <i>et al.</i>	(ATLAS Collab.)
KHACHATRY...	15AW	JHEP 1510 144	V. Khachatryan <i>et al.</i>	(CMS Collab.)
KHACHATRY...	15AY	JHEP 1511 071	V. Khachatryan <i>et al.</i>	(CMS Collab.)
KHACHATRY...	15BB	PL B750 494	V. Khachatryan <i>et al.</i>	(CMS Collab.)
KHACHATRY...	15N	PL B748 221	V. Khachatryan <i>et al.</i>	(CMS Collab.)
KHACHATRY...	15O	PL B748 255	V. Khachatryan <i>et al.</i>	(CMS Collab.)
KHACHATRY...	15R	PL B749 560	V. Khachatryan <i>et al.</i>	(CMS Collab.)
LEES	15H	PR D91 071102	J.P. Lees <i>et al.</i>	(BABAR Collab.)
AAD	14AP	PRL 113 171801	G. Aad <i>et al.</i>	(ATLAS Collab.)
AAD	14AW	JHEP 1411 056	G. Aad <i>et al.</i>	(ATLAS Collab.)
AAD	14BA	JHEP 1411 088	G. Aad <i>et al.</i>	(ATLAS Collab.)
AAD	14M	PR D89 032002	G. Aad <i>et al.</i>	(ATLAS Collab.)
AAD	14O	PRL 112 201802	G. Aad <i>et al.</i>	(ATLAS Collab.)
CHATRCHYAN	14B	EPJ C74 2980	S. Chatrchyan <i>et al.</i>	(CMS Collab.)
CHATRCHYAN	14G	JHEP 1401 096	S. Chatrchyan <i>et al.</i>	(CMS Collab.)
KHACHATRY...	14M	JHEP 1410 160	V. Khachatryan <i>et al.</i>	(CMS Collab.)
KHACHATRY...	14P	EPJ C74 3076	V. Khachatryan <i>et al.</i>	(CMS Collab.)
KHACHATRY...	14Q	PR D90 112013	V. Khachatryan <i>et al.</i>	(CMS Collab.)
AAD	13AG	PL B721 32	G. Aad <i>et al.</i>	(ATLAS Collab.)
AAD	13AT	NJP 15 043009	G. Aad <i>et al.</i>	(ATLAS Collab.)
AAD	13O	JHEP 1302 095	G. Aad <i>et al.</i>	(ATLAS Collab.)
AAIJ	13T	JHEP 1305 132	R. Aaij <i>et al.</i>	(LHCb Collab.)
AALTONEN	13K	PR D88 052012	T. Aaltonen <i>et al.</i>	(CDF Collab.)
AALTONEN	13L	PR D88 052013	T. Aaltonen <i>et al.</i>	(CDF Collab.)
AALTONEN	13M	PR D88 052014	T. Aaltonen <i>et al.</i>	(CDF and D0 Collabs.)
AALTONEN	13P	PRL 110 121801	T. Aaltonen <i>et al.</i>	(CDF Collab.)
ABAZOV	13G	PR D88 052006	V.M. Abazov <i>et al.</i>	(D0 Collab.)
ABAZOV	13H	PR D88 052007	V.M. Abazov <i>et al.</i>	(D0 Collab.)
ABAZOV	13I	PR D88 052008	V.M. Abazov <i>et al.</i>	(D0 Collab.)
ABAZOV	13J	PR D88 052009	V.M. Abazov <i>et al.</i>	(D0 Collab.)
ABAZOV	13L	PR D88 052011	V.M. Abazov <i>et al.</i>	(D0 Collab.)
CARENA	13	EPJ C73 2552	M. Carena <i>et al.</i>	
CHATRCHYAN	13AG	PL B722 207	S. Chatrchyan <i>et al.</i>	(CMS Collab.)
CHATRCHYAN	13AL	PL B725 36	S. Chatrchyan <i>et al.</i>	(CMS Collab.)
CHATRCHYAN	13BJ	PL B726 564	S. Chatrchyan <i>et al.</i>	(CMS Collab.)
LEES	13C	PR D87 031102	J.P. Lees <i>et al.</i>	(BABAR Collab.)
LEES	13L	PR D88 031701	J.P. Lees <i>et al.</i>	(BABAR Collab.)
LEES	13R	PR D88 071102	J.P. Lees <i>et al.</i>	(BABAR Collab.)
AAD	12AI	PL B716 1	G. Aad <i>et al.</i>	(ATLAS Collab.)
AAD	12AQ	PRL 108 251801	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	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	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.)
ABLIKIM	12	PR D85 092012	M. Ablikim <i>et al.</i>	(BESIII 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	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	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	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.)
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.)
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. Schael <i>et al.</i>	(ALEPH 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	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. Schael <i>et al.</i>	(ALEPH Collab.)
LEP-SLC	06	PRPL 427 257	ALEPH, DELPHI, L3, OPAL, SLD and working groups	
SCHAEEL	06B	EPJ C47 547	S. Schael <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	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.)
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.)
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.)
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	
KRAWCZYK	97	PR D55 6968	M. Krawczyk, J. Zochowski	(WARS)
ALEXANDER	96H	ZPHY C71 1	G. Alexander <i>et al.</i>	(OPAL 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.)

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(CERN, CPPM)
(Crystal Ball Collab.)
