Measurements of the properties of the new boson with a mass near 125 GeV

This is a condensed description with plots for the analysis CMS-PAS-HIG-13-005.

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"); //document.write("full range: "); link_4grid(x+"_logx"); document.write("
"); //document.write("linear scale: "); link_4grid(x+""); } } function preview_auto(x) { if (x.match(/(fc|mlz)_ccc.*|_fc_|summary|qvals.root/)) { document.write("."); } else if (x.match(/^7\/.*(mlz)/)) { var xS0 = x.replace(/^(([78]\/)?)/, "sqr_"); document.write("."); document.write("."); } else if (x.match(/mass_scan_1d_all/)) { var xS0 = x.replace(/^(([78]\/)?)/, "sqr_"); var xS2 = xS0.replace(/_1d_all/,"_2d_all_white") document.write("."); document.write("."); } else if (x.match(/scan_2d_all_68/)) { var xS0 = x.replace(/^(([78]\/)?)/, "$1sqr_"); //var xS9 = xS0.replace(/_68/,"_95"); document.write("."); //document.write("."); } else if (x.match(/cVcF_all_channels_1quadrant/)) { var xu = x.replace(/1quad/,"2quad"); document.write("."); document.write("."); } else if (x.match(/_cut_/) && x.match(/scan_[12]d/)) { var xS0 = x.replace(/^(([78]\/)?)/, "$1sqr_"); var xSU = xS0.replace(/cut_/,""); document.write("."); document.write("."); } else if (x.match(/scan_2d/) && !x.match(/_slice_|_prof_/)) { var xS0 = x.replace(/^(([78]\/)?)/, "$1sqr_"); var xSC = xS0.replace(/$/,"_col"); document.write("."); document.write("."); } else if (x.match(/scan_1d/) || (x.match(/scan_2d/) && x.match(/_slice_|_prof_/))) { var xS0 = x.replace(/^(([78]\/)?)/, "$1sqr_"); document.write("."); } else if (x.match(/c3|vhbb|htt|hgg|hzz2|vhww3|zoom|mlz_mlz|cvcf|mass_scan|rwz/)) { var xS0 = x.replace(/^(([78]\/)?)/, "$1sqr_"); document.write("."); } else { document.write("."); document.write("."); } } function do_it(x) { document.write("
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Sensitivities and significances of the observed excess in the individual decay modes

	Significance (m_H = 125.7 GeV)		
Combination	**Expected (pre-fit)**	**Expected (post-fit)**	**Observed**
H ZZ	7.1	7.1	6.7
H	4.2	3.9	3.2
H WW	5.6	5.3	3.9
H bb	2.1	2.2	2.0
H	2.7	2.6	2.8
H and H bb	3.5	3.4	3.4

The expected significance is computed for the background + SM signal hypothesis (with μ=1). The pre-fit expected significance is computed for the nominal value of the nuisance parameters, while the post-fit expected significance is computed setting the nuisance parameters to their best-fit values.

Mass of the observed state

Plot	Caption
	(Left) **1D test statistics q(m_H) scan vs hypothesized Higgs boson mass m_H** for the and 4l final states separately and for their combination. In

	this combination, three independent signal strengths gg H , VBF+VH H , and H ZZ 4l are profiled together with all other nuisance parameters. (Right) **2D 68% CL contours for a hypothesized Higgs boson mass m_H and signal strength / $_{SM}$** for the and 4l, and their combination. In this combination, the relative signal strengths are constrained by the expectations for the SM Higgs boson.
	1D test statistics $q(m_H)$ scan vs hypothesized Higgs boson mass m_H for the combination of the high resolution channels. 1D-scans of the test statistic $q(m_X)$ versus hypothesized boson mass m_X for the combination of the and 4l final states. The solid line is obtained with all nuisance parameters profiled and, hence, includes both statistical and systematic uncertainties. The dashed line is obtained with all nuisance parameters fixed to their best-fit values and, hence, includes only statistical uncertainties. The crossings with the thick (thin) horizontal lines define the 68% (95%) CL interval for the measured mass.

Additional plots

Plot	Caption
\	**1D test statistics −*2 ln Q* vs hypothesized Higgs boson mass m_H for the diphoton final state.** The solid line is obtained with all nuisance parameters profiled and, hence, includes both statistical and systematic uncertainties. The dashed line is obtained with all nuisance parameters fixed to their best-fit values and, hence, includes only statistical uncertainties. The crossings with the thick (thin) horizontal lines define the 68% (95%) CL interval for the measured mass.
\	**1D test statistics −*2 ln Q* vs hypothesized Higgs boson mass m_H for the four-lepton final state.** The solid line is obtained with all nuisance parameters profiled and, hence, includes both statistical and systematic uncertainties. The dashed line is obtained with all nuisance parameters fixed to their best-fit values and, hence, includes only statistical uncertainties. The crossings with the thick (thin) horizontal lines define the 68% (95%) CL interval for the measured mass.
	2D test statistics −*2 ln Q* vs hypothesized Higgs boson mass m_H and signal strength / $_{SM}$ for the combination of the high resolution channels. The cross indicates the best-fit values. The solid, dashed, and dotted contours show the 68%, 95%, and 99.7% CL ranges, respectively. In this combination, the relative signal strengths for the various final states are constrained by the expectations for the SM Higgs boson.
	2D test statistics −*2 ln Q* vs hypothesized Higgs boson mass m_H and signal strength / $_{SM}$ for the diphoton final state. The cross indicates the best-fit values. The solid, dashed, and dotted contours show the 68%, 95%, and 99.7% CL ranges, respectively. In this combination, the relative signal strengths for the various production modes are constrained by the expectations for the SM Higgs boson.
	2D test statistics −*2 ln Q* vs hypothesized Higgs boson mass m_H and signal strength / $_{SM}$ for the four-lepton final state. The cross indicates the best-fit values. The solid, dashed, and dotted contours show the 68%, 95%, and 99.7% CL ranges, respectively.

Compatibility of the observed state with the SM Higgs boson hypothesis: signal strengths

Plot	Caption
	Values of μ = / $_{SM}$ for the combination (solid vertical line) and for contributing channels (points). The vertical band shows the overall μ value 0.80 ± 0.14. The horizontal bars indicate the ±1 uncertainties on the μ values for individual channels; they include both statistical and systematic uncertainties.
	Values of μ = / $_{SM}$ for the combination (solid vertical line) and for sub-combinations grouped by decay mode (points). The vertical band shows the overall μ value 0.80 ± 0.14. The horizontal bars indicate the ±1 uncertainties on the μ values for individual channels; they include both statistical and systematic uncertainties.
	Values of μ = / $_{SM}$ for the combination (solid vertical line) and for sub-combinations grouped by a signature enhancing specific production mechanisms (points). The vertical band shows the overall μ value 0.80 ± 0.14. The horizontal bars indicate the ±1 uncertainties on the μ values for individual channels; they include both statistical and systematic uncertainties.
	(Left plot) The 68% CL intervals for signal strength in the gluon-gluon-fusion-plus-ttH and in VBF-plus-VH production mechanisms: $\mu_{ggH,ttH}$ and $\mu_{VBF,VH}$, respectively. The different colors show the results obtained by combining data from each of the five analayzed decay modes: (green), WW (blue), ZZ(red), (violet), bb (cyan). The crosses indicate the best-fit values. The diamond at (1,1) indicates the expected values for the SM Higgs boson.

Additional plots not in PAS

Plot	Caption
	Values of μ = / $_{SM}$ for the the individual channels. The horizontal bars indicate the ±1 uncertainties on the μ values for individual channels; they include both statistical and systematic uncertainties. The vertical dashed line indicates the prediction for a SM Higgs boson.
	Values of μ = / $_{SM}$ for the sub-combinations by decay mode. The horizontal bars indicate the ±1 uncertainties on the μ values for individual channels; they include both statistical and systematic uncertainties. The vertical dashed line indicates the prediction for a SM Higgs boson.
	Values of μ = / $_{SM}$ for the sub-combinations grouped by a signature enhancing specific production mechanisms. The horizontal bars indicate the ±1 uncertainties on the μ values for individual channels; they include both statistical and systematic uncertainties. The vertical dashed line indicates the prediction for a SM Higgs boson.

Numeric values

The tables below contain the same information that is shown in figures 3a-3c of the HIG-13-005 PAS.

Channel	μ = / $_{SM}$ (m_H = 125.7 GeV)	
by production tag and decay mode	**value**	**uncertainty**
H bb (VH tag)	1.306	-0.608 / +0.682
H bb (ttH tag)	-0.150	-2.903 / +2.820
H (untagged)	0.700	-0.289 / +0.326
H (VBF tag)	1.010	-0.535 / +0.628
H (VH tag)	0.571	-1.135 / +1.340
H WW (VBF tag)	-0.047	-0.555 / +0.747
H WW (0/1 jet)	0.725	-0.197 / +0.220
H WW (VH tag)	0.510	-0.942 / +1.256
H (0/1 jet)	0.770	-0.551 / +0.577
H (VBF tag)	1.423	-0.637 / +0.696
H (VH tag)	0.981	-1.496 / +1.680
H ZZ (0/1 jet)	0.858	-0.258 / +0.321
H ZZ (2 jets)	1.235	-0.583 / +0.852
by decay mode	**value**	**uncertainty**
H bb	1.148	-0.595 / +0.646
H	1.100	-0.397 / +0.432
H	0.772	-0.259 / +0.289
H WW	0.679	-0.186 / +0.205
H ZZ	0.919	-0.247 / +0.301
by production tag	**value**	**uncertainty**
Untagged	0.779	-0.150 / +0.169
VBF tag	1.017	-0.312 / +0.357
VH tag	1.020	-0.468 / +0.503
ttH tag	-0.150	-2.903 / +2.820

Production modes

Likelihood scan results for a fit to the data assuming independent signal strengths for each of the four production modes, while the decay branching fractions are assumed to be as in the SM.

Plot	Caption
	1D test statistics $q(\mu_{ggH})$ scan vs the signal strength modifier for gluon-fusion production μ_{ggH}, profiling the signal strength modifiers for the other production modes μ_{VBF},μ_{VH},μ_{ttH} and all other nuisances. The decay branching fractions are assumed to be as in the SM.
	1D test statistics $q(\mu_{VBF})$ scan vs the signal strength modifier for vector-boson-fusion production μ_{VBF}, profiling the signal strength modifiers for the other production modes μ_{ggH},μ_{VH},μ_{ttH} and all other nuisances. The decay branching fractions are assumed to be as in the SM.
	1D test statistics $q(\mu_{VH})$ scan vs the signal strength modifier for associated VH production μ_{VH}, profiling the signal strength modifiers for the other production modes μ_{ggH},μ_{VBF},μ_{ttH} and all

	other nuisances. The decay branching fractions are assumed to be as in the SM.

Impact of theoretical uncertainties on inclusive production cross sections (not in PAS)

Likelihood scan results for a fit to the data assuming independent signal strengths for each of the four production modes, while the decay branching fractions are assumed to be as in the SM. Results are shown with and without the theoretical uncertainties from higher order terms on inclusive production cross sections; acceptance, jet-bin, PDF and underlying-event uncertainties are always included.

Plot	Caption
	1D test statistics q(μ_{ggH}) scan vs the signal strength modifier for gluon-fusion production μ_{ggH}, profiling the signal strength modifiers for the other production modes μ_{VBF},μ_{VH},μ_{ttH} and all other nuisances. The decay branching fractions are assumed to be as in the SM.
	1D test statistics q(μ_{VBF}) scan vs the signal strength modifier for vector-boson-fusion production μ_{VBF}, profiling the signal strength modifiers for the other production modes μ_{ggH},μ_{VH},μ_{ttH} and all other nuisances. The decay branching fractions are assumed to be as in the SM.
	1D test statistics q(μ_{VH}) scan vs the signal strength modifier for associated VH production μ_{VH}, profiling the signal strength modifiers for the other production modes μ_{ggH},μ_{VBF},μ_{ttH} and all other nuisances. The decay branching fractions are assumed to be as in the SM.

Ratio of production modes (not in PAS)

Likelihood scan results for a fit to the data of the ratio of signal strengths in associated VBF and VH production ($\mu_{VBF,VH}$) and the other productions modes ($\mu_{ggH,ttH}$). Using this ratio ($\mu_{VBF,VH}/\mu_{ggH,ttH}$) the branching fractions fractions cancel out in each decay channel and the results of the different channels can be combined.

The best-fit $\mu_{VBF,VH}/\mu_{ggH,ttH} = 1.538^{+1.161}_{-0.743}$ for a 3.21 standard deviation significance against a zero ratio.

Plot	Caption
	1D test statistics q($\mu_{VBF,VH}/\mu_{ggH,ttH}$) scan vs the ratio of signal strength modifiers $\mu_{VBF,VH}/\mu_{ggH,ttH}$, profiling all other nuisances, for the different decay channels considered and their combination. The cross-section ratios $_{VBF}/_{VH}$ and $_{ggH}/_{ttH}$ assumed to be as in the SM.
	1D test statistics q($\mu_{VBF,VH}/\mu_{ggH,ttH}$) scan vs the ratio of signal strength modifiers $\mu_{VBF,VH}/\mu_{ggH,ttH}$, profiling all other nuisances, for the combination of different decay channels as well as the SM expectation. The cross-section ratios $_{VBF}/_{VH}$ and $_{ggH}/_{ttH}$ assumed to be as in the SM.

Tests for deviations of the couplings

Test of Fermion and Vector Boson Couplings

Plot	Caption
	2D test statistics q($_{V}$, $_{F}$) scan.

	2D test statistics q($_{V}$, $_{F}$) scan, including individual channels.

Additional plots not in PAS

	1D test statistics q($_{V}$) scan, profiling $_{F}$.
	1D test statistics q($_{F}$) scan, profiling $_{V}$.
	1D test statistics q($_{V}$) scan, if $_{F}$ is fixed to the SM value ($_{F}$=1).
	1D test statistics q($_{F}$) scan, if $_{V}$ is fixed to the SM value ($_{V}$=1).

Test of Custodial Symmetry

Using only untagged WW and ZZ events and assuming SM couplings to fermions

Plot	Caption
	1D test statistics q($_{WZ}$) scan vs the coupling modifier ratio $_{WZ}$, profiling the coupling modifier $_{Z}$ and all other nuisances. The coupling to fermions is taken to be the SM one ($_{F}$ = 1).

Additional correlation plot not in PAS

Plot	Caption
	2D test statistics q($_{WZ}$, $_{Z}$) scan, profiling $_{F}$ and all other nuisances. The coupling to fermions is taken to be the SM one ($_{F}$ = 1).

Using all channels, and without assumption on the couplings to fermions (except their universality)

Plot	Caption
	1D test statistics q($_{WZ}$) scan vs the coupling modifier ratio $_{WZ}$, profiling the coupling modifiers $_{Z}$ and $_{F}$ and all other nuisances.

Additional correlation plots not in PAS

Plot	Caption
	2D test statistics q($_{WZ}$, $_{Z}$) scan, profiling the coupling modifier to fermions $_{F}$ and all other nuisances.
	2D test statistics q($_{WZ}$, $_{F}$) scan, profiling the coupling modifier to the Z boson $_{Z}$ and all other nuisances.

Test of Fermion Universality

Up-type vs Down-type Fermions

Plot	Caption
	1D test statistics q($_{du}$) scan vs the coupling modifier ratio $_{du}$, profiling the coupling modifiers $_{u}$ and $_{V}$ and all other nuisances. $_{u}$ and $_{V}$ are always taken to be positive.

Additional correlation plots not in PAS

Plot	Caption
	2D test statistics q($_{du}$, $_{u}$) scan, profiling the coupling modifier to vector bosons $_{V}$ and all other nuisances. $_{u}$ and $_{V}$ are always taken to be positive.
	2D test statistics q($_{V}$, $_{u}$) scan, profiling the modifier to the ratio of up-type and down-type couplings $_{du}$ and all other nuisances.

Leptons vs Quarks

Plot	Caption
	1D test statistics q($_{lq}$) scan vs the coupling modifier ratio $_{lq}$, profiling the coupling modifiers $_{q}$ and $_{V}$ and all other nuisances. $_{q}$ and $_{V}$ are always taken to be positive.

Additional correlation plots not in PAS

Plot	Caption
	2D test statistics q($_{lq}$, $_{q}$) scan, profiling the coupling modifier to vector bosons $_{V}$ and all other nuisances. $_{q}$ and $_{V}$ are always taken to be positive.
	2D test statistics q($_{lq}$, $_{V}$) scan, profiling the coupling modifier to the quarks $_{q}$ and all other nuisances. $_{q}$ and $_{V}$ are always taken to be positive.
	2D test statistics q($_{V}$, $_{q}$) scan, profiling the modifier to the ratio of lepton to quark couplings $_{lq}$ and all other nuisances.

Search for Beyond Standard Model Physics in Loops

Plot	Caption
	2D test statistics q($_{g}$,) scan.

Additional plots not in PAS

Plot	Caption
	1D test statistics q($_{g}$) scan, profiling the modifier to the effective coupling to photons .
	1D test statistics q( ) scan, profiling the modifier to the effective coupling to gluons $_{g}$.

Additional plots including Z (not in PAS)

For this fit, the Z analysis from HIG-13-006 is included, and an extra coupling modifier $_{Z}$ is added to the model to parametrize this loop-induced coupling.
Limits are set in the 2D plane (, $_{Z}$), profiling the modifier to the gluon effective coupling $_{g}$, and assuming the tree-level couplings to be as in the SM (= 1).

Plot	Caption
	2D test statistics q($_{g}$, $_{Z}$) scan, profiling the modifier to the effective coupling to gluons $_{g}$.

Search for Beyond Standard Model Physics in Loops and Decays

Plot	Caption
	1D test statistics q(BR_{BSM}) scan, profiling the modifier to the effective coupling to photons and gluons , $_{g}$.
	2D test statistics q($_{g}$, BR_{BSM}) scan, profiling the modifier to the effective coupling to photons .

Generic search for deviations in the couplings (with effective photon and gluon couplings)

The search is performed with five independent coupling modifiers: $_{V}$, $_{b}$, , $_{t}$, $_{g}$, .

Plot	Caption
	1D test statistics q($_{V}$) scan, profiling the other five coupling modifiers.
	1D test statistics q($_{b}$) scan, profiling the other five coupling modifiers.
	1D test statistics q( ) scan, profiling the other five coupling modifiers.
	1D test statistics q($_{t}$) scan, profiling the other five coupling modifiers.
	1D test statistics q( ) scan, profiling the other five coupling modifiers.
	1D test statistics q($_{g}$) scan, profiling the other five coupling modifiers.

Including BSM decays

Plot	Caption
	The likelihood scan versus BR_{BSM} = $_{BSM}$/ $_{tot}$. The solid curve is the data and the dashed line indicates the expected median results in the presence of the SM Higgs boson. The modifiers for both the tree-level and loop-induced couplings are profiled, but the couplings to the electroweak bosons are assumed to be bound by the SM expectation ($_{V} \leq 1$)

Generic search for deviations in the couplings (assuming SM loop structure) (not in PAS)

The search is performed with five independent coupling modifiers: $_{W}$, $_{Z}$, $_{b}$, , $_{t}$.

Plot	Caption
	1D test statistics q($_{W}$) scan, profiling the other four coupling modifiers.
	1D test statistics q($_{Z}$) scan, profiling the other four coupling modifiers.
	1D test statistics q($_{b}$) scan, profiling the other four coupling modifiers.
	1D test statistics q( ) scan, profiling the other four coupling modifiers.

	1D test statistics q($_t$) scan, profiling the other four coupling modifiers.

Summary plots of couplings

Plot	Caption
	Summary of the fits for deviations in the coupling for the LHC XS WG benchmark models (arXiv:1209.0040). For each model, the best fit values of the most interesting parameters are shown, with the corresponding 68% and 95% CL intervals, and the overall p-value p_{SM} of the SM Higgs hypothesis is given. The list of parameters for each model and the numerical values of the intervals are provided in Table 3 of the PAS.
	Summary of the fits for deviations in the coupling for the generic six-parameter model including effective loop couplings. The best fit of the parameters are shown, with the corresponding 68% and 95% CL intervals, and the overall p-value p_{SM} of the SM Higgs hypothesis is given. The result of the fit when extending the model to allow for beyond-SM decays while restricting the effective coupling to vector bosons to not exceed unity ($_V$ ≤ 1.0) is also shown.
	Summary of the fits for deviations in the coupling for the generic five-parameter model not effective loop couplings. In this model, loop-induced couplings are assumed to follow the SM structure as in arXiv:1209.0040. The best fit values of the parameters are shown, with the corresponding 68% and 95% CL intervals, and the overall p-value p_{SM} of the SM Higgs hypothesis is given.
	Summary of the fits for deviations in the coupling for the generic five-parameter model not effective loop couplings, expressed as function of the particle mass. For the fermions, the values of the fitted yukawa couplings *hff* are shown, while for vector bosons the square-root of the coupling for the *hVV* vertex divided by twice the vacuum expectation value of the Higgs boson field. Particle masses (in the MS-bar scheme) and the vacuum expectation value of the Higgs boson are taken from the PDG. In this model, loop-induced couplings are assumed to follow the SM structure as in arXiv:1209.0040.
	Summary of the fits for deviations in the coupling for the generic five-parameter model not effective loop couplings, expressed as function of the particle mass. For the fermions, the values of the fitted yukawa couplings *hff* are shown, while for vector bosons the square-root of the coupling for the *hVV* vertex divided by twice the vacuum expectation value of the Higgs boson field. Particle masses for leptons and weak boson, and the vacuum expectation value of the Higgs boson are taken from the PDG. For the top quark the same mass used in theoretical calculations is used (172.5 GeV) and for the bottom quark the running mass $m_b(m_H=125.7\ \text{GeV})=2.763$ GeV is used. In this model, loop-induced couplings are assumed to follow the SM structure as in arXiv:1209.0040.

Combined WW + ZZ results for spin 2

Plot	Caption
	Post-fit model distributions of the test statistic comparing the signal J^P hypotheses 0^+ and $2^+_m(gg)$ in the best fit to the data.

	The observed value is indicated by the arrow and disfavours the 2^+_m(gg) signal hypothesis with a CLs value of 0.6%.
	Pre-fit model distributions of the test statistic comparing the signal J^P hypotheses 0^+ and 2^+_m(gg). The median expected CLs value of the 2^+_m(gg) hypothesis for a SM Higgs boson is 0.2%.

Additional plots for WW and ZZ alone

Plot	Caption
	H ZZ: post-fit model distributions of the test statistic comparing the signal J^P hypotheses 0^+ and 2^+_m(gg) in the best fit to the data. The observed value is indicated by the arrow and disfavours the 2^+_m(gg) signal hypothesis with a CLs value of 1.3%.
	H ZZ: pre-fit model distributions of the test statistic comparing the signal J^P hypotheses 0^+ and 2^+_m(gg). The median expected CLs value of the 2^+_m(gg) hypothesis for a SM Higgs boson is 6.8%.
	H WW: post-fit model distributions of the test statistic comparing the signal J^P hypotheses 0^+ and 2^+_m(gg) in the best fit to the data. The observed value is indicated by the arrow and disfavours the 2^+_m(gg) signal hypothesis with a CLs value of 14.0%
	H WW: pre-fit model distributions of the test statistic comparing the signal J^P hypotheses 0^+ and 2^+_m(gg). The median expected CLs value of the 2^+_m(gg) hypothesis for a SM Higgs boson is 1.4%.

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