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Letter

Constraint on the total width of the Higgs boson from Higgs boson and four-top-quark measurements in pp collisions at $\sqrt{s} = 13$ TeV with the ATLAS detector

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ABSTRACT

This Letter presents a constraint on the total width of the Higgs boson (Γ_H) using a combined measurement of on-shell Higgs boson production and the production of four top quarks, which involves contributions from off-shell Higgs boson-mediated processes. This method relies on the assumption that the tree-level Higgs-top Yukawa coupling strength is the same for on-shell and off-shell Higgs boson production processes, thereby avoiding any assumptions about the relationship between on-shell and off-shell gluon fusion Higgs production rates, which were central to previous measurements. The result is based on up to 140 fb^{-1} of proton–proton collisions at a centre-of-mass energy of $\sqrt{s} = 13$ TeV collected with the ATLAS detector at the Large Hadron Collider. The observed (expected) 95% confidence level upper limit on Γ_H is 450 MeV (75 MeV). Additionally, considering the constraint on the Higgs-top Yukawa coupling from loop-induced Higgs boson production and decay processes further yields an observed (expected) upper limit of 160 MeV (55 MeV).

1. Introduction

The discovery of the Higgs boson [1–6] by the ATLAS [7] and CMS [8] collaborations at the Large Hadron Collider (LHC) has ushered in a new era for particle physics, marked by precision measurements in the Higgs sector. The total width of the Higgs boson (Γ_H) is sensitive to the potential presence of beyond the Standard Model (SM) Higgs boson decays that are not covered by direct experimental searches, making it a crucial parameter for exploring new phenomena. The Higgs boson mass has been measured to be 125.09 ± 0.24 GeV based on LHC Run 1 data collected by the ATLAS and CMS experiments [9], and more recently to be 125.11 ± 0.11 GeV based on Run 1 and Run 2 data collected by the ATLAS experiment [10]. At the measured Higgs boson mass value around 125 GeV, the SM predicts the value of Γ_H to be only 4.1 MeV [11]. Due to limited detector resolution, the total width of the Higgs boson is inaccessible via direct measurement of the Higgs boson line shape or flight distance [12] at the LHC experiments. However, a combined measurement of on-shell and off-shell Higgs boson production processes can constrain the total width of the Higgs boson based on specific model assumptions [13–16]. The on-shell Higgs boson production and decay rates depend on both the Higgs boson coupling strength to particles involved in the production and decay processes, and the total width of the Higgs boson. In contrast, the off-shell Higgs boson production and decay depend only on the off-shell Higgs coupling strength. If the relation between the on-shell and off-shell Higgs boson couplings is known, the combined measurement of on-shell and off-shell Higgs boson production processes allows the determination of Γ_H.

Recently, both the ATLAS and CMS experiments placed constraints on Γ_H using combined measurements of on-shell and off-shell Higgs boson production processes in the $ZZ^{(*)}$ final states, yielding 95% confidence level (CL) upper limits of 10.2 MeV [17] and 8.5 MeV [18], respectively, superseding earlier constraints obtained by the two experiments with Run 1 data using the same assumptions [19,20]. These measurements assume that the strength modifiers, which are multiplicative factors of the Higgs boson couplings, are the same between off-shell and on-shell production processes specifically for its interactions with gluons and vector bosons. However, the loop-induced effective Higgs-gluon coupling could vary differently between on-shell and off-shell production processes if not-yet-detected coloured beyond SM (BSM) particles are contributing to the Higgs-gluon coupling [21–23].

This Letter presents a constraint on Γ_H using a combined measurement of on-shell Higgs boson production in association with a top-quark pair ($t\bar{t}H$) and the simultaneous production of four top quarks ($t\bar{t}t\bar{t}$), which involves contributions from off-shell Higgs boson-mediated processes through the Higgs-top Yukawa coupling. Fig. 1 shows representative Feynman diagrams of those processes involving a Higgs boson in the final state or a virtual Higgs boson mediator. This measurement assumes that the tree-level Higgs-top Yukawa coupling strength is the same for

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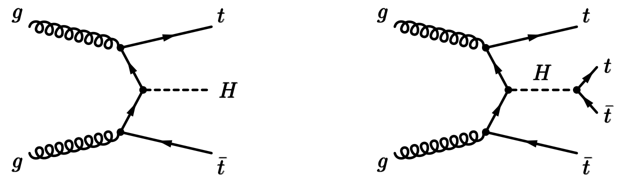

(a) (b)

Fig. 1. Example leading-order Feynman diagrams for the (a) $t\bar{t}H$ and (b) Higgs-mediated $t\bar{t}t\bar{t}$ processes.

Table 1
Summary of on-shell and off-shell measurements used as input for the total width measurement. For the on-shell analyses, this table specifically breaks down the processes targeted by the measurement into production and decay modes. The off-shell measurement is included but not broken down in this manner.

Target processes		Reference
Off-shell measurement		
$pp \to t\bar{t}t\bar{t}$		[26]
On-shell measurement		
Production	Decay	
ggF, VBF, WH, ZH, $t\bar{t}H$, tH	$H \to \gamma\gamma$	[31]
$t\bar{t}H + tH$	$H \to b\bar{b}$	[32]
WH, ZH	$H \to b\bar{b}$	[33,34]
VBF	$H \to b\bar{b}$	[35]
ggF, VBF, $WH + ZH$, $t\bar{t}H + tH$	$H \to ZZ$	[36]
ggF, VBF	$H \to WW$	[37]
WH, ZH	$H \to WW$	[38]
ggF, VBF, $WH + ZH$, $t\bar{t}H + tH$	$H \to \tau\tau$	[39]
ggF+ $t\bar{t}H + tH$, VBF+ $WH + ZH$	$H \to \mu\mu$	[40]
Inclusive	$H \to Z\gamma$	[41]

on-shell and off-shell Higgs boson production processes [24,25]. Different from the Higgs-gluon coupling, the presence of unknown coloured particles would not modify the tree-level Higgs-top Yukawa coupling and its scale dependence. Another assumption made in this study is that no BSM contributions affect the $t\bar{t}t\bar{t}$ production. Both ATLAS and CMS experiments have observed $t\bar{t}t\bar{t}$ production in proton–proton (pp) collisions at $\sqrt{s} = 13$ TeV and used the measurements to set constraints on possible BSM contributions that may affect this process [26,27]. In summary, the constraint on Γ_H derived from the combined measurement of the $t\bar{t}H$ and $t\bar{t}t\bar{t}$ processes represents a complementary approach based on different assumptions from existing studies [17,18].

2. Input measurements

This combined measurement uses results from individual measurements performed by the ATLAS experiment [28] as input, summarised in Table 1. The sensitivity to the total width of the Higgs boson primarily comes from the $t\bar{t}H$ and $t\bar{t}t\bar{t}$ processes. However, measurements targeting other Higgs boson production modes are also included to constrain contributions from Higgs boson couplings beyond its top Yukawa coupling. These additional modes include gluon–gluon fusion (ggF), vector boson fusion (VBF), associated production with a vector boson (WH/ZH), and associated production with a single top quark (tH), which also contributes to the Higgs-top Yukawa coupling measurement.

The input measurements rely on the two-level trigger system used to select the events [29], and a software suite [30] that is used in data simulation, in the reconstruction and analysis of real and simulated data, in detector operations, and in the trigger and data acquisition systems of the experiment.

An overview of the on-shell Higgs boson measurements is detailed in Ref. [42]. Based on pp collision data collected by the ATLAS experiment during LHC Run 2 at a centre-of-mass energy of $\sqrt{s} = 13$ TeV, corresponding to integrated luminosities ranging from 36.1 fb^{-1} to 139 fb^{-1}, the $t\bar{t}H$ cross-section is determined to be 0.37 ± 0.12 pb assuming SM Higgs boson decay branching ratios. The measured value is in agreement with the SM prediction of 0.50 ± 0.05 pb [11]. The sensitivity is mainly contributed by the $H \to \gamma\gamma$ [31], $H \to b\bar{b}$ [32], and multi-lepton [43] final states. In the $H \to \gamma\gamma$ analysis, a multi-class Boosted Decision Trees (BDT) classifier is first used to divide data into regions enriched with $t\bar{t}H$ or Higgs bosons produced through other modes. Then binary BDT classifiers are deployed to further discriminate the target signal from background processes. The $t\bar{t}H$ signal is extracted by fitting the diphoton invariant mass spectra in categories defined by the multi-class and binary BDT boundaries. The background is estimated from data-driven interpolation in the data side-band. The $H \to b\bar{b}$ analysis, on the other hand, first separates data into one-lepton and dilepton final states (electrons or muons), with the presence of b-tagged jets, then uses either a BDT or a Deep Neural Network (DNN) algorithm to reconstruct the Higgs boson. A classification BDT is used to further separate the $t\bar{t}H$ signal from background processes. The $t\bar{t}H$ signal cross-section is extracted by fitting the classification BDT score distribution to data in most analysis categories. The dominant background is from the $t\bar{t}(+\geq 1b)$ process, which is modelled by Monte Carlo (MC) simulation with its normalisation determined from data. Finally, the measurement from the multi-lepton final states [43], which includes contributions from $H \to ZZ$, $H \to WW$, and $H \to \tau\tau$ decays, is removed from the work reported in this Letter due to its partial overlap with the $t\bar{t}t\bar{t}$ data set [26]. After the removal, the overlap of data sets between the on-shell measurement and the $t\bar{t}t\bar{t}$ measurement is negligible.

The measurement of $t\bar{t}t\bar{t}$ production is detailed in Ref. [26]. It uses pp collision data at $\sqrt{s} = 13$ TeV from LHC Run 2, corresponding to an integrated luminosity of 140 fb^{-1}. Events with multi-lepton final states are selected, specifically those with two leptons of the same electric charge or at least three leptons (electrons or muons). These events are also required to have at least two b-tagged jets. Major background processes include $t\bar{t}W$, $t\bar{t}Z$, and $t\bar{t}H$ processes, with dedicated control regions defined to constrain the corresponding templates built from MC simulation. The rates of fake and non-prompt lepton background and charge mis-assignment background are also estimated and corrected using data-driven methods. A Graph Neural Network (GNN) classifier is used to further separate the $t\bar{t}t\bar{t}$ signal from background processes. The $t\bar{t}t\bar{t}$ cross-section is measured by fitting the GNN score distribution to data. The observed significance of the $t\bar{t}t\bar{t}$ signal is 6.1 standard deviations (σ), with an expected significance of $4.3\,\sigma$. The measured $t\bar{t}t\bar{t}$ production cross-section is $22.5^{+6.6}_{-5.5}$ fb, consistent with the SM prediction of 12.0 ± 2.4 fb [44–46] within $1.8\,\sigma$.

3. Combination framework

The combined measurement uses the profile likelihood ratio and its asymptotic distribution to set upper limits on the total width of the Higgs boson [47,48]. The likelihood function of this combined measurement incorporates systematic uncertainties as constrained nuisance parameters and correlates those consistently defined between input measurements. To incorporate the updated ATLAS integrated luminosity measurement [49] since the publication of Ref. [42], the luminosity uncertainties in the on-shell measurement are revised and correlated with the $t\bar{t}t\bar{t}$ measurement. In addition, the uncertainties in the reconstruction and calibration of electrons, muons, jets, and missing transverse momentum, the uncertainty in the pile-up modelling by the MC simulation, and the theory uncertainties in $t\bar{t}H$, $t\bar{t}t\bar{t}$, and $t\bar{t}Z$ MC modelling are all treated as correlated between the on-shell and $t\bar{t}t\bar{t}$ measurements. The impact from the potential correlation in other systematic uncertainties between the on-shell and $t\bar{t}t\bar{t}$ measurements on the upper limit of Γ_H is checked and found to be negligible. The expected results corresponding to the SM prediction are evaluated based on an Asimov data set [48], which is generated with a set of nuisance parameters determined by a fit to data where the signal cross-sections are fixed to their SM values.

To parameterise the event rates of on-shell and off-shell Higgs boson production processes, the so-called κ-framework [50] is adopted. The signal strength of any Higgs boson production and decay process $i \to H \to f$ in the on-shell measurement, defined as the ratio of the total Higgs boson signal yield to its SM prediction, is parameterised as $\kappa_i^2 \kappa_f^2 / (\Gamma_H / \Gamma_H^{SM})$ under the narrow-width approximation, where κ_i and κ_f are the coupling strength parameters modifying the production and decay rates, respectively, and Γ_H^{SM} is the SM value of the total width of the Higgs boson. The strength parameters for the tree-level couplings to top quark (κ_t), bottom quark (κ_b), tau-lepton (κ_τ), muon (κ_μ), and weak bosons (κ_Z and κ_W) are free parameters determined by the data. The strength parameters for the three loop-induced effective couplings, namely, the Higgs-gluon coupling (κ_g), the Higgs-photon coupling (κ_γ), and the Higgs-Z-photon coupling ($\kappa_{(Z\gamma)}$), are free parameters in the fit as well. The coupling for the $gg \to ZH$ process $\kappa_{(ggZH)}$, on the other hand, is parameterised as a function of κ_Z and κ_t. The current data set does not have the statistical power to constrain the $gg \to ZH$ process. The $t\bar{t}t\bar{t}$ process is a minor background in the $t\bar{t}H$, $H \to b\bar{b}$ measurement, and its normalisation is fixed to the SM prediction within uncertainties. The constraint on the Higgs-top Yukawa coupling strength κ_t primarily comes from the $t\bar{t}H$ production cross-section measurement. As a cross-check of this constraint, a fit is performed by parameterising Γ_H as a function of coupling strengths for SM particles based on the data used in the on-shell measurement. The fit yields κ_t to be 0.86 ± 0.13. This is 9% lower than the value reported in Ref. [42] due to the removal of the $t\bar{t}H$ multi-lepton final states from the on-shell measurement. The uncertainty in κ_t also increases by 18% when removing the $t\bar{t}H$ multi-lepton final state.

For the $t\bar{t}t\bar{t}$ measurement, the expected signal production rate in each bin of the GNN classifier discriminant is parameterised as a polynomial in κ_t, up to $\mathcal{O}(\kappa_t^4)$. The constant term arises from $t\bar{t}t\bar{t}$ production mediated by gluons or Z/γ^*, the $\mathcal{O}(\kappa_t^2)$ term arises from the interference between off-shell Higgs boson-mediated production and gluon- or Z/γ^*-mediated production, and the $\mathcal{O}(\kappa_t^4)$ term represents the contribution from off-shell Higgs boson-mediated production. There are no terms at odd orders of κ_t since there are always two Higgs-top Yukawa coupling vertices in the Higgs-mediated $t\bar{t}t\bar{t}$ production diagrams. The polynomial is derived based on leading-order MC simulation samples [26]. The $t\bar{t}H$ process is included in the $t\bar{t}t\bar{t}$ measurement as a background, and its normalisation is a free parameter determined from data. As discussed in Section 4, this treatment has a small impact on the determination of Γ_H. Using this configuration, the $t\bar{t}t\bar{t}$ measurement yields an observed (expected) 95% CL upper limit on $|\kappa_t|$ of 2.3 (1.9) [26]. This observation is consistent with the SM at 1.8 standard deviations.

4. Results

With κ_t and other Higgs boson coupling strength parameters as described in Section 3 profiled, the observed (expected) combined 95% CL upper limit on Γ_H is 450 MeV (75 MeV), corresponding to 110 (18) times the SM prediction. The profile likelihood ratio as a function of Γ_H is shown in Fig. 2. The observed value of the total width of the Higgs boson is $\Gamma_H = 86^{+110}_{-49}$ MeV, which is $2.0\,\sigma$ away from the SM expectation. The tension with the SM prediction arises primarily from the $1.8\,\sigma$ difference between data and SM prediction in the $t\bar{t}t\bar{t}$ measurement. Assuming the loop-induced ggF, $H \to \gamma\gamma$, and $H \to Z\gamma$ rates can be modelled as a function of κ_t and other SM coupling strengths [42,50], the observed (expected) 95% CL upper limit on Γ_H becomes 160 MeV (55 MeV) owing to the better constraint on κ_t contributed by these loop-induced processes. The deviation from the SM expectation in Γ_H under this alternative scenario remains $2.0\,\sigma$.

The 68% and 95% CL contours in the Γ_H and κ_t plane are shown in Fig. 3. Because of the degeneracy among coupling strength parameters and Γ_H in the on-shell measurement, the best-fit value of $\kappa_t = 1.9$ is

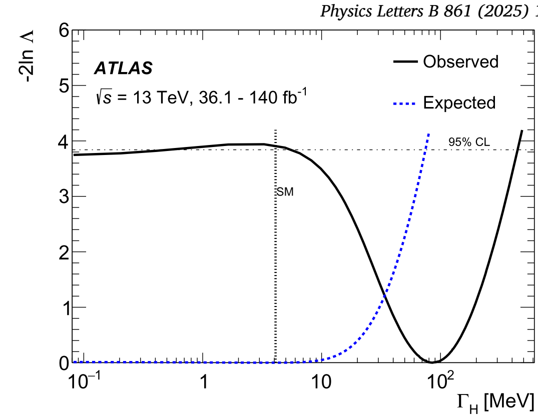

Fig. 2. The observed (expected) profile likelihood ratio, $-2\ln\Lambda$, as a function of Γ_H is shown as a solid (dashed) line. The Higgs-top Yukawa coupling strength κ_t and other Higgs boson coupling strength parameters as described in Section 3 are profiled. The 95% confidence interval is indicated by the intersections of the horizontal line with the $-2\ln\Lambda$ curves. The vertical line indicates the SM prediction.

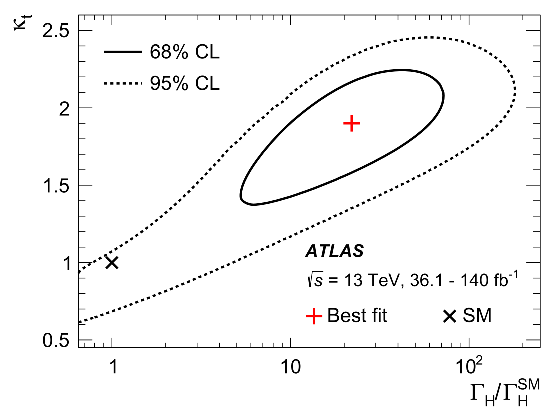

Fig. 3. The 68% CL (solid line) and 95% CL (dashed line) contours for a simultaneous measurement of Γ_H normalised to the SM prediction and κ_t. The best-fit value and the SM prediction are also indicated in the figure.

determined by the measurement of $t\bar{t}t\bar{t}$ cross-section that is larger than the SM prediction. The best-fit value of Γ_H is in turn scaled together with κ_t and other coupling strengths parameters along the flat direction of the likelihood function for the on-shell measurement.

The Higgs boson decay contributions from the minor $t\bar{t}H$ background in the $t\bar{t}t\bar{t}$ measurement were not incorporated into the κ-framework based event rate parameterisation because the input measurement did not preserve information about the relative fractions of various Higgs decay final states in the signal region. However, this has minimal impacts on the interpretation. Up to a 6% (2%) decrease in the observed (expected) limit on Γ_H is estimated when the $t\bar{t}H$ background in the $t\bar{t}t\bar{t}$ measurement is parameterised as functions of Γ_H and κ_t in the combined fit, assuming either a 100% $H \to WW$ or a 100% $H \to \tau\tau$ branching ratio. Note that the $H \to WW$ and $H \to \tau\tau$ are the two leading Higgs boson decay channels that contribute to the multi-lepton final state targeted by the $t\bar{t}t\bar{t}$ measurement. The assumption of full branching ratios is expected to provide a maximum estimate of the impact. Similarly, the input on-shell measurement did not consider the contribution from the $t\bar{t}t\bar{t}$ process in constraining κ_t. When the $t\bar{t}t\bar{t}$ normalisation in the $t\bar{t}H$, $H \to b\bar{b}$ measurement is parameterised as a function of κ_t [24] in the combined fit, the observed (expected) limit on Γ_H changes by 0.6% (0.5%).

The impact of various groups of systematic uncertainties in Γ_H is evaluated by individually removing each group from the fit. This is achieved by fixing the associated nuisance parameters to their best-fit

Table 2
Impact of the main sources of systematic uncertainties in the expected and observed 95% CL upper limit on the total width of the Higgs boson Γ_H. The impact is quantified as the reduction of the upper limit when the corresponding systematic uncertainties are removed from consideration by fixing the associated nuisance parameters at the best-fit values. The impacts shown here are not a breakdown of uncertainties, and one does not expect that the quadratic sum of individual impact values will be the same as the total impact value.

Systematic uncertainty	Impact on 95% CL upper limit on Γ_H Expected [%]	Observed [%]
Theory	37	33
$t\bar{t}t\bar{t}$ production	25	13
Higgs boson production/decay	5	6
Other processes	10	16
Experimental	2	2
Jet flavour tagging	2	1
Jet and missing transverse energy	< 1	< 1
Leptons and photons	< 1	< 1
All other systematic uncertainties	< 1	< 1

values and then quantifying the change in the upper limit on Γ_H. As shown in Table 2, theory uncertainties have the most significant impact on the result. The largest impact on the expected limit, at 25%, comes from the theory uncertainties in the $t\bar{t}t\bar{t}$ process, which include missing higher-order QCD corrections evaluated from varying renormalisation and factorisation scales, MC generator choices, and the parton shower modelling. Details of the $t\bar{t}t\bar{t}$ MC simulated sample are provided in Ref. [26]. Conversely, the largest impact on the observed limit, at 16%, arises from the theory uncertainty in other physics processes, notably the $t\bar{t}(+\geq 1b)$ background in the $t\bar{t}H$, $H\rightarrow b\bar{b}$ measurement. Due to a larger-than-SM best-fit value, the uncertainty in the $t\bar{t}t\bar{t}$ cross-section measurement has a smaller observed impact on the Γ_H measurement than in the expected case, owing to the non-linear mapping between the two measurements. Experimental uncertainties, such as those in jet energy calibration and flavour tagging, contribute only a 2% impact on the limit. Removing all systematic uncertainties would decrease the observed (expected) upper limit to 280 MeV (44 MeV).

5. Conclusions

In this Letter a constraint on the total width of the Higgs boson Γ_H is obtained through a combination of measurements of on-shell Higgs boson production and $t\bar{t}t\bar{t}$ production with contribution from the off-shell $H\rightarrow t\bar{t}$ process. The input analyses are based on up to 140 fb^{-1} of pp collisions at a centre-of-mass energy of $\sqrt{s}=13$ TeV, collected with the ATLAS detector at the LHC. The study assumes that the Higgs-top Yukawa coupling strength κ_t remains the same between the on-shell and off-shell regimes. The resulting 95% CL upper limit on Γ_H is 450 MeV, corresponding to 110 times the SM prediction, while the expected upper limit is 75 MeV, corresponding to 18 times the SM prediction. Assuming that only SM particles contribute to the loop-induced gluon–gluon fusion, $H\rightarrow\gamma\gamma$, and $H\rightarrow Z\gamma$ processes, the observed (expected) upper limit decreases to 160 MeV (55 MeV). The tension between the data and the SM prediction is $2.0\,\sigma$ in both scenarios, driven by the $1.8\,\sigma$ difference between data and SM in the $t\bar{t}t\bar{t}$ measurement. This result represents the first constraint on the total width of the Higgs boson using both on-shell and off-shell production processes involving the Higgs-top Yukawa coupling. It explores model assumptions distinct from those employed in similar studies based on diboson final states, thereby testing the robustness of our current understanding of the Higgs boson total width.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Data availability

The data for this manuscript are not available. The values in the plots and tables associated to this article are stored in HEPDATA (http://hepdata.cedar.ac.uk)

References

[1] F. Englert, R. Brout, Broken symmetry and the mass of gauge vector mesons, Phys. Rev. Lett. 13 (1964) 321.

[2] P.W. Higgs, Broken symmetries, massless particles and gauge fields, Phys. Lett. 12 (1964) 132.

[3] P.W. Higgs, Broken symmetries and the masses of gauge bosons, Phys. Rev. Lett. 13 (1964) 508.

[4] P.W. Higgs, Spontaneous symmetry breakdown without massless bosons, Phys. Rev. 145 (1966) 1156.

[5] G.S. Guralnik, C.R. Hagen, T.W.B. Kibble, Global conservation laws and massless particles, Phys. Rev. Lett. 13 (1964) 585.

[6] T.W.B. Kibble, Symmetry breaking in non-Abelian gauge theories, Phys. Rev. 155 (1967) 1554.

[7] ATLAS Collaboration, Observation of a new particle in the search for the Standard Model Higgs boson with the ATLAS detector at the LHC, Phys. Lett. B 716 (2012) 1, arXiv:1207.7214 [hep-ex].

[8] CMS Collaboration, Observation of a new boson at a mass of 125 GeV with the CMS experiment at the LHC, Phys. Lett. B 716 (2012) 30, arXiv:1207.7235 [hep-ex].

[9] ATLAS CMS Collaborations, Combined measurement of the Higgs boson mass in pp collisions at $\sqrt{s} = 7$ and 8 TeV with the ATLAS and CMS experiments, Phys. Rev. Lett. 114 (2015) 191803, arXiv:1503.07589 [hep-ex].

[10] ATLAS Collaboration, Combined measurement of the Higgs boson mass from the $H \to \gamma\gamma$ and $H \to ZZ^* \to 4\ell$ decay channels with the ATLAS detector using $\sqrt{s} = 7, 8,$ and 13 TeV pp collision data, Phys. Rev. Lett. 131 (2023) 251802, arXiv:2308.04775 [hep-ex].

[11] D. de Florian, et al., Handbook of LHC Higgs cross sections: 4. Deciphering the nature of the Higgs sector, arXiv:1610.07922 [hep-ph], 2017.

[12] CMS Collaboration, Limits on the Higgs boson lifetime and width from its decay to four charged leptons, Phys. Rev. D 92 (2015) 072010, arXiv:1507.06656 [hep-ex].

[13] N. Kauer, G. Passarino, Inadequacy of zero-width approximation for a light Higgs boson signal, J. High Energy Phys. 08 (2012) 116, arXiv:1206.4803 [hep-ph].

[14] F. Caola, K. Melnikov, Constraining the Higgs boson width with ZZ production at the LHC, Phys. Rev. D 88 (2013) 054024, arXiv:1307.4935 [hep-ph].

[15] J.M. Campbell, R.K. Ellis, C. Williams, Bounding the Higgs width at the LHC using full analytic results for $gg \to e^-e^+\mu^-\mu^+$, J. High Energy Phys. 04 (2014) 060, arXiv:1311.3589 [hep-ph].

[16] J.M. Campbell, R.K. Ellis, C. Williams, Bounding the Higgs width at the LHC: complementary results from $H \to WW$, Phys. Rev. D 89 (2014) 053011, arXiv:1312.1628 [hep-ph].

[17] ATLAS Collaboration, Evidence of off-shell Higgs boson production from ZZ leptonic decay channels and constraints on its total width with the ATLAS detector, Phys. Lett. B 846 (2023) 138223, arXiv:2304.01532 [hep-ex], Phys. Lett. B 854 (2024) 138734, Erratum.

[18] CMS Collaboration, Measurement of the Higgs boson width and evidence of its off-shell contributions to ZZ production, Nat. Phys. 18 (2022) 1329, arXiv:2202.06923 [hep-ex].

[19] ATLAS Collaboration, Constraints on the off-shell Higgs boson signal strength in the high-mass ZZ and WW final states with the ATLAS detector, Eur. Phys. J. C 75 (2015) 335, arXiv:1503.01060 [hep-ex].

[20] CMS Collaboration, Search for Higgs boson off-shell production in proton–proton collisions at 7 and 8 TeV and derivation of constraints on its total decay width, J. High Energy Phys. 09 (2016) 051, arXiv:1605.02329 [hep-ex].

[21] M. Buschmann, et al., Mass effects in the Higgs-gluon coupling: boosted vs off-shell production, J. High Energy Phys. 02 (2015) 038, arXiv:1410.5806 [hep-ph].

[22] C. Englert, M. Spannowsky, Limitations and opportunities of off-shell coupling measurements, Phys. Rev. D 90 (2014) 053003, arXiv:1405.0285 [hep-ph].

[23] Q.-H. Cao, H.-L. Li, L.-X. Xu, J.-H. Yu, What can we learn from the total width of the Higgs boson?, Chin. Phys. C 47 (2023) 033101, arXiv:2107.08343 [hep-ph].

[24] Q.-H. Cao, S.-L. Chen, Y. Liu, Probing Higgs width and top quark Yukawa coupling from $t\bar{t}H$ and $t\bar{t}t\bar{t}$ productions, Phys. Rev. D 95 (2017) 053004, arXiv:1602.01934 [hep-ph].

[25] Q.-H. Cao, S.-L. Chen, Y. Liu, R. Zhang, Y. Zhang, Limiting top quark-Higgs boson interaction and Higgs-boson width from multitop productions, Phys. Rev. D 99 (2019) 113003, arXiv:1901.04567 [hep-ph].

[26] ATLAS Collaboration, Observation of four-top-quark production in the multilepton final state with the ATLAS detector, Eur. Phys. J. C 83 (2023) 496, arXiv:2303.15061 [hep-ex], Eur. Phys. J. C 84 (2024) 156, Erratum.

[27] CMS Collaboration, Observation of four top quark production in proton–proton collisions at $\sqrt{s} = 13$ TeV, Phys. Lett. B 847 (2023) 138290, arXiv:2305.13439 [hep-ex].

[28] ATLAS Collaboration, The ATLAS experiment at the CERN large hadron collider, J. Instrum. 3 (2008) S08003.

[29] ATLAS Collaboration, Performance of the ATLAS trigger system in 2015, Eur. Phys. J. C 77 (2017) 317, arXiv:1611.09661 [hep-ex].

[30] ATLAS Collaboration, The ATLAS simulation infrastructure, Eur. Phys. J. C 70 (2010) 823, arXiv:1005.4568 [physics.ins-det].

[31] ATLAS Collaboration, Measurement of the properties of Higgs boson production at $\sqrt{s} = 13$ TeV in the $H \to \gamma\gamma$ channel using 139 fb^{-1} of pp collision data with the ATLAS experiment, J. High Energy Phys. 07 (2023) 088, arXiv:2207.00348 [hep-ex].

[32] ATLAS Collaboration, Measurement of Higgs boson decay into b-quarks in associated production with a top-quark pair in pp collisions at $\sqrt{s} = 13$ TeV with the ATLAS detector, J. High Energy Phys. 06 (2022) 097, arXiv:2111.06712 [hep-ex].

[33] ATLAS Collaboration, Measurements of WH and ZH production in the $H \to b\bar{b}$ decay channel in pp collisions at 13 TeV with the ATLAS detector, Eur. Phys. J. C 81 (2021) 178, arXiv:2007.02873 [hep-ex].

[34] ATLAS Collaboration, Measurement of the associated production of a Higgs boson decaying into b-quarks with a vector boson at high transverse momentum in pp collisions at $\sqrt{s} = 13$ TeV with the ATLAS detector, Phys. Lett. B 816 (2021) 136204, arXiv:2008.02508 [hep-ex].

[35] ATLAS Collaboration, Measurements of Higgs bosons decaying to bottom quarks from vector boson fusion production with the ATLAS experiment at $\sqrt{s} = 13$ TeV, Eur. Phys. J. C 81 (2021) 537, arXiv:2011.08280 [hep-ex].

[36] ATLAS Collaboration, Higgs boson production cross-section measurements and their EFT interpretation in the 4ℓ decay channel at $\sqrt{s} = 13$ TeV with the ATLAS detector, Eur. Phys. J. C 80 (2020) 957, arXiv:2004.03447 [hep-ex], Eur. Phys. J. C 81 (2021) 29, Erratum, Eur. Phys. J. C 81 (2021) 398, Erratum.

[37] ATLAS Collaboration, Measurements of Higgs boson production by gluon–gluon fusion and vector-boson fusion using $H \to WW^* \to e\nu\mu\nu$ decays in pp collisions at $\sqrt{s} = 13$ TeV with the ATLAS detector, Phys. Rev. D 108 (2023) 032005, arXiv:2207.00338 [hep-ex].

[38] ATLAS Collaboration, Measurement of the production cross section for a Higgs boson in association with a vector boson in the $H \to WW^* \to \ell\nu\ell\nu$ channel in pp collisions at $\sqrt{s} = 13$ TeV with the ATLAS detector, Phys. Lett. B 798 (2019) 134949, arXiv:1903.10052 [hep-ex].

[39] ATLAS Collaboration, Measurements of Higgs boson production cross-sections in the $H \to \tau^+\tau^-$ decay channel in pp collisions at $\sqrt{s} = 13$ TeV with the ATLAS detector, J. High Energy Phys. 08 (2022) 175, arXiv:2201.08269 [hep-ex].

[40] ATLAS Collaboration, A search for the dimuon decay of the Standard Model Higgs boson with the ATLAS detector, Phys. Lett. B 812 (2021) 135980, arXiv:2007.07830 [hep-ex].

[41] ATLAS Collaboration, A search for the $Z\gamma$ decay mode of the Higgs boson in pp collisions at $\sqrt{s} = 13$ TeV with the ATLAS detector, Phys. Lett. B 809 (2020) 135754, arXiv:2005.05382 [hep-ex].

[42] ATLAS Collaboration, A detailed map of Higgs boson interactions by the ATLAS experiment ten years after the discovery, Nature 607 (2022) 52, arXiv:2207.00092 [hep-ex], Nature 612 (2022) E24, Erratum.

[43] ATLAS Collaboration, Evidence for the associated production of the Higgs boson and a top quark pair with the ATLAS detector, Phys. Rev. D 97 (2018) 072003, arXiv:1712.08891 [hep-ex].

[44] R. Frederix, D. Pagani, M. Zaro, Large NLO corrections in $t\bar{t}W^{\pm}$ and $t\bar{t}t\bar{t}$ hadroproduction from supposedly subleading EW contributions, J. High Energy Phys. 02 (2018) 031, arXiv:1711.02116 [hep-ph].

[45] G. Bevilacqua, M. Worek, Constraining BSM Physics at the LHC: four top final states with NLO accuracy in perturbative QCD, J. High Energy Phys. 07 (2012) 111, arXiv:1206.3064 [hep-ph].

[46] T. Ježo, M. Kraus, Hadroproduction of four top quarks in the powheg box, Phys. Rev. D 105 (2022) 114024, arXiv:2110.15159 [hep-ph].

[47] The ATLAS Collaboration, The CMS Collaboration, The LHC Higgs combination group, in: Procedure for the LHC Higgs Boson Search Combination in Summer 2011, 2011, ATL-PHYS-PUB-2011-011, https://cds.cern.ch/record/1375842.

[48] G. Cowan, K. Cranmer, E. Gross, O. Vitells, Asymptotic formulae for likelihood-based tests of new physics, Eur. Phys. J. C 71 (2011) 1554, arXiv:1007.1727 [physics.data-an], Eur. Phys. J. C 73 (2013) 2501, Erratum.

[49] ATLAS Collaboration, Luminosity determination in pp collisions at $\sqrt{s} = 13$ TeV using the ATLAS detector at the LHC, Eur. Phys. J. C 83 (2023) 982, arXiv:2212.09379 [hep-ex].

[50] J.R. Andersen, et al., Handbook of LHC Higgs cross sections: 3. Higgs Properties, arXiv:1307.1347 [hep-ph], 2013.

[51] ATLAS Collaboration, ATLAS computing acknowledgements, ATL-SOFT-PUB-2023-001, https://cds.cern.ch/record/2869272, 2023.

The ATLAS Collaboration

G. Aad [104], E. Aakvaag [17], B. Abbott [123], S. Abdelhameed [119a], K. Abeling [56], N.J. Abicht [50], S.H. Abidi [30], M. Aboelela [45], A. Aboulhorma [36e], H. Abramowicz [155], H. Abreu [154], Y. Abulaiti [120], B.S. Acharya [70a,70b,l], A. Ackermann [64a], C. Adam Bourdarios [4], L. Adamczyk [87a], S.V. Addepalli [27], M.J. Addison [103], J. Adelman [118], A. Adiguzel [22c], T. Adye [137], A.A. Affolder [139], Y. Afik [40], M.N. Agaras [13], J. Agarwala [74a,74b], A. Aggarwal [102], C. Agheorghiesei [28c], F. Ahmadov [39,aa], W.S. Ahmed [106], S. Ahuja [97], X. Ai [63e], G. Aielli [77a,77b], A. Aikot [166], M. Ait Tamlihat [36e], B. Aitbenchikh [36a], M. Akbiyik [102], T.P.A. Åkesson [100], A.V. Akimov [38], D. Akiyama [171], N.N. Akolkar [25], S. Aktas [22a], K. Al Khoury [42], G.L. Alberghi [24b], J. Albert [168], P. Albicocco [54], G.L. Albouy [61], S. Alderweireldt [53], Z.L. Alegria [124], M. Aleksa [37], I.N. Aleksandrov [39], C. Alexa [28b], T. Alexopoulos [10], F. Alfonsi [24b], M. Algren [57], M. Alhroob [170], B. Ali [135], H.M.J. Ali [93,t], S. Ali [32], S.W. Alibocus [94], M. Aliev [34c], G. Alimonti [72a], W. Alkakhi [56], C. Allaire [67], B.M.M. Allbrooke [150], J.S. Allen [103], J.F. Allen [53], C.A. Allendes Flores [140f], P.P. Allport [21], A. Aloisio [73a,73b], F. Alonso [92], C. Alpigiani [142], Z.M.K. Alsolami [93], M. Alvarez Estevez [101], A. Alvarez Fernandez [102], M. Alves Cardoso [57], M.G. Alviggi [73a,73b], M. Aly [103], Y. Amaral Coutinho [84b], A. Ambler [106], C. Amelung [37], M. Amerl [103], C.G. Ames [111], D. Amidei [108], B. Amini [55], K.J. Amirie [158], S.P. Amor Dos Santos [133a], K.R. Amos [166], D. Amperiadou [156], S. An [85], V. Ananiev [128], C. Anastopoulos [143], T. Andeen [11], J.K. Anders [37], A.C. Anderson [60], S.Y. Andrean [48a,48b], A. Andreazza [72a,72b], S. Angelidakis [9], A. Angerami [42], A.V. Anisenkov [38], A. Annovi [75a], C. Antel [57], E. Antipov [149], M. Antonelli [54], F. Anulli [76a], M. Aoki [85], T. Aoki [157], M.A. Aparo [150], L. Aperio Bella [49], C. Appelt [19], A. Apyan [27], S.J. Arbiol Val [88], C. Arcangeletti [54], A.T.H. Arce [52], J-F. Arguin [110], S. Argyropoulos [156], J.-H. Arling [49], O. Arnaez [4], H. Arnold [149], G. Artoni [76a,76b], H. Asada [113], K. Asai [121], S. Asai [157], N.A. Asbah [37], R.A. Ashby Pickering [170], K. Assamagan [30], R. Astalos [29a], K.S.V. Astrand [100], S. Atashi [162], R.J. Atkin [34a], M. Atkinson [165], H. Atmani [36f], P.A. Atmasiddha [131], K. Augsten [135], S. Auricchio [73a,73b], A.D. Auriol [21], V.A. Austrup [103], G. Avolio [37], K. Axiotis [57], G. Azuelos [110,af], D. Babal [29b], H. Bachacou [138], K. Bachas [156,p], A. Bachiu [35], E. Bachmann [51], F. Backman [48a,48b], A. Badea [40], T.M. Baer [108], P. Bagnaia [76a,76b], M. Bahmani [19], D. Bahner [55], K. Bai [126], J.T. Baines [137], L. Baines [96], O.K. Baker [175], E. Bakos [16], D. Bakshi Gupta [8], L.E. Balabram Filho [84b], V. Balakrishnan [123], R. Balasubramanian [4], E.M. Baldin [38], P. Balek [87a], E. Ballabene [24b,24a], F. Balli [138], L.M. Baltes [64a], W.K. Balunas [33], J. Balz [102], I. Bamwidhi [119b], E. Banas [88], M. Bandieramonte [132], A. Bandyopadhyay [25], S. Bansal [25], L. Barak [155], M. Barakat [49], E.L. Barberio [107], D. Barberis [58b,58a], M. Barbero [104], M.Z. Barel [117], T. Barillari [112], M-S. Barisits [37], T. Barklow [147], P. Baron [125], D.A. Baron Moreno [103], A. Baroncelli [63a], A.J. Barr [129], J.D. Barr [98], F. Barreiro [101], J. Barreiro Guimarães da Costa [14], U. Barron [155], M.G. Barros Teixeira [133a], S. Barsov [38], F. Bartels [64a], R. Bartoldus [147], A.E. Barton [93],

P. Bartos [29a], A. Basan [102], M. Baselga [50], A. Bassalat [67,b], M.J. Basso [159a], S. Bataju [45], R. Bate [167], R.L. Bates [60], S. Batlamous [101], B. Batool [145], M. Battaglia [139], D. Battulga [19], M. Bauce [76a,76b], M. Bauer [80], P. Bauer [25], L.T. Bazzano Hurrell [31], J.B. Beacham [52], T. Beau [130], J.Y. Beaucamp [92], P.H. Beauchemin [161], P. Bechtle [25], H.P. Beck [20,o], K. Becker [170], A.J. Beddall [83], V.A. Bednyakov [39], C.P. Bee [149], L.J. Beemster [16], T.A. Beermann [37], M. Begalli [84d], M. Begel [30], A. Behera [149], J.K. Behr [49], J.F. Beirer [37], F. Beisiegel [25], M. Belfkir [119b], G. Bella [155], L. Bellagamba [24b], A. Bellerive [35], P. Bellos [21], K. Beloborodov [38], D. Benchekroun [36a], F. Bendebba [36a], Y. Benhammou [155], K.C. Benkendorfer [62], L. Beresford [49], M. Beretta [54], E. Bergeaas Kuutmann [164], N. Berger [4], B. Bergmann [135], J. Beringer [18a], G. Bernardi [5], C. Bernius [147], F.U. Bernlochner [25], F. Bernon [37], A. Berrocal Guardia [13], T. Berry [97], P. Berta [136], A. Berthold [51], S. Bethke [112], A. Betti [76a,76b], A.J. Bevan [96], N.K. Bhalla [55], S. Bhatta [149], D.S. Bhattacharya [169], P. Bhattarai [147], K.D. Bhide [55], V.S. Bhopatkar [124], R.M. Bianchi [132], G. Bianco [24b,24a], O. Biebel [111], R. Bielski [126], M. Biglietti [78a], C.S. Billingsley [45], Y. Bimgdi [36f], M. Bindi [56], A. Bingul [22b], C. Bini [76a,76b], G.A. Bird [33], M. Birman [172], M. Biros [136], S. Biryukov [150], T. Bisanz [50], E. Bisceglie [44b,44a], J.P. Biswal [137], D. Biswas [145], I. Bloch [49], A. Blue [60], U. Blumenschein [96], J. Blumenthal [102], V.S. Bobrovnikov [38], M. Boehler [55], B. Boehm [169], D. Bogavac [37], A.G. Bogdanchikov [38], L.S. Boggia [130], C. Bohm [48a], V. Boisvert [97], P. Bokan [37], T. Bold [87a], M. Bomben [5], M. Bona [96], M. Boonekamp [138], C.D. Booth [97], A.G. Borbély [60], I.S. Bordulev [38], G. Borissov [93], D. Bortoletto [129], D. Boscherini [24b], M. Bosman [13], J.D. Bossio Sola [37], K. Bouaouda [36a], N. Bouchhar [166], L. Boudet [4], J. Boudreau [132], E.V. Bouhova-Thacker [93], D. Boumediene [41], R. Bouquet [58b,58a], A. Boveia [122], J. Boyd [37], D. Boye [30], I.R. Boyko [39], L. Bozianu [57], J. Bracinik [21], N. Brahimi [4], G. Brandt [174], O. Brandt [33], F. Braren [49], B. Brau [105], J.E. Brau [126], R. Brener [172], L. Brenner [117], R. Brenner [164], S. Bressler [172], G. Brianti [79a,79b], D. Britton [60], D. Britzger [112], I. Brock [25], R. Brock [109], G. Brooijmans [42], E.M. Brooks [159b], E. Brost [30], L.M. Brown [168], L.E. Bruce [62], T.L. Bruckler [129], P.A. Bruckman de Renstrom [88], B. Brüers [49], A. Bruni [24b], G. Bruni [24b], M. Bruschi [24b], N. Bruscino [76a,76b], T. Buanes [17], Q. Buat [142], D. Buchin [112], A.G. Buckley [60], O. Bulekov [38], B.A. Bullard [147], S. Burdin [94], C.D. Burgard [50], A.M. Burger [37], B. Burghgrave [8], O. Burlayenko [55], J. Burleson [165], J.T.P. Burr [33], J.C. Burzynski [146], E.L. Busch [42], V. Büscher [102], P.J. Bussey [60], J.M. Butler [26], C.M. Buttar [60], J.M. Butterworth [98], W. Buttinger [137], C.J. Buxo Vazquez [109], A.R. Buzykaev [38], S. Cabrera Urbán [166], L. Cadamuro [67], D. Caforio [59], H. Cai [132], Y. Cai [14,114c], Y. Cai [114a], V.M.M. Cairo [37], O. Cakir [3a], N. Calace [37], P. Calafiura [18a], G. Calderini [130], P. Calfayan [69], G. Callea [60], L.P. Caloba [84b], D. Calvet [41], S. Calvet [41], M. Calvetti [75a,75b], R. Camacho Toro [130], S. Camarda [37], D. Camarero Munoz [27], P. Camarri [77a,77b], M.T. Camerlingo [73a,73b], D. Cameron [37], C. Camincher [168], M. Campanelli [98], A. Camplani [43], V. Canale [73a,73b], A.C. Canbay [3a], E. Canonero [97], J. Cantero [166], Y. Cao [165], F. Capocasa [27], M. Capua [44b,44a], A. Carbone [72a,72b], R. Cardarelli [77a], J.C.J. Cardenas [8], G. Carducci [44b,44a], T. Carli [37], G. Carlino [73a], J.I. Carlotto [13], B.T. Carlson [132,q], E.M. Carlson [168,159a], J. Carmignani [94], L. Carminati [72a,72b], A. Carnelli [138], M. Carnesale [37], S. Caron [116], E. Carquin [140f], I.B. Carr [107], S. Carrá [72a], G. Carratta [24b,24a], A.M. Carroll [126], M.P. Casado [13,i], M. Caspar [49], F.L. Castillo [4], L. Castillo Garcia [13], V. Castillo Gimenez [166], N.F. Castro [133a,133e], A. Catinaccio [37], J.R. Catmore [128], T. Cavaliere [4], V. Cavaliere [30], N. Cavalli [24b,24a], L.J. Caviedes Betancourt [23b], Y.C. Cekmecelioglu [49], E. Celebi [83], S. Cella [37], M.S. Centonze [71a,71b], V. Cepaitis [57], K. Cerny [125], A.S. Cerqueira [84a],

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