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Combined measurement of differential and total cross sections in the $H \to \gamma\gamma$ and the $H \to ZZ^* \to 4\ell$ decay channels at $\sqrt{s} = 13$ TeV with the ATLAS detector

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ABSTRACT

A combined measurement of differential and inclusive total cross sections of Higgs boson production is performed using 36.1 fb^{-1} of 13 TeV proton–proton collision data produced by the LHC and recorded by the ATLAS detector in 2015 and 2016. Cross sections are obtained from measured $H \to \gamma\gamma$ and $H \to ZZ^* \to 4\ell$ event yields, which are combined taking into account detector efficiencies, resolution, acceptances and branching fractions. The total Higgs boson production cross section is measured to be $57.0^{+6.0}_{-5.9}$ (stat.) $^{+4.0}_{-3.3}$ (syst.) pb, in agreement with the Standard Model prediction. Differential cross-section measurements are presented for the Higgs boson transverse momentum distribution, Higgs boson rapidity, number of jets produced together with the Higgs boson, and the transverse momentum of the leading jet. The results from the two decay channels are found to be compatible, and their combination agrees with the Standard Model predictions.

1. Introduction

Differential cross-section measurements are important studies of Higgs boson production, probing Standard Model (SM) predictions. Deviations from the predictions could be caused by physics beyond the SM [1,2]. Both the ATLAS and CMS collaborations have measured differential cross sections in the $H \to \gamma\gamma$, $H \to ZZ^* \to 4\ell$ (where $\ell = e, \mu$) and $H \to WW^* \to e\nu\mu\nu$ decay channels [3–10].

This Letter describes the combination of two fiducial cross-section measurements in the $H \to \gamma\gamma$ [11] and $H \to ZZ^* \to 4\ell$ [12] decay channels, which were obtained using 36.1 fb^{-1} of pp collision data produced by the Large Hadron Collider (LHC) in 2015 and 2016 with a centre-of-mass energy of 13 TeV and recorded by the ATLAS detector [13]. The combined cross section is extracted for the total phase space, increasing the degree of model dependence compared to the individual measurements, which were performed in a fiducial phase space close to the selection criteria for reconstructed events in the detector. Despite the additional systematic uncertainties assigned to the extrapolation to the total phase space, the combination significantly reduces the measurement uncertainty compared to the results in the individual decay channels.

The measured observables include the total production cross section, the Higgs boson's transverse momentum p_T^H, sensitive to perturbative QCD calculations, and the Higgs boson's rapidity $|y^H|$, sensitive to the parton distribution functions (PDF). Furthermore the number of jets N_{jets} is measured in events with a Higgs boson and jet transverse momentum above 30 GeV, as well as the leading jet's transverse momentum p_T^{j1}. Both the N_{jets} and p_T^{j1} observables probe the theoretical modelling of high-p_T QCD radiation in Higgs boson production. The N_{jets} observable is also sensitive to the different Higgs boson production processes [14].

The cross sections are obtained from yields measured in the $H \to \gamma\gamma$ and $H \to ZZ^* \to 4\ell$ decay channels, which are combined taking into account detector efficiencies, resolution, acceptances and branching fractions. For each decay channel and each observable, the cross sections can be written as

$$\sigma_i = \frac{N_i^{\text{sig}}}{L\, \mathcal{B}\, \mathcal{A}_i\, \mathcal{C}_i},$$

where i is the iterator over the bins of the observable of interest, σ_i is the cross section in bin i, N_i^{sig} is the number of measured reconstructed signal events following the analysis selection, L is the integrated luminosity and $\mathcal{B}$ is the branching fraction. The term $\mathcal{C}_i$ is the correction factor from the number of events reconstructed to the number of events at particle level produced in the respective fiducial phase space, and $\mathcal{A}_i$ is the acceptance factor extrapolating

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Table 1
Monte Carlo samples used to simulate Higgs boson production, including the generators, accuracy of calculations in QCD, and PDF sets.

Process	Generator	Accuracy in QCD	PDF set
ggF	Powheg-Box v2 (NNLOPS) [20–23]	NNLO in $\lvert y^H \rvert$ [24], p_T^H consistent with HqT (NNLO + NNLL) [26,27]	PDF4LHC [25]
VBF	Powheg-Box v2 [20–22,28]	NLO	PDF4LHC
VH	Powheg-Box v2 (MiNLO) [20–22,29]	NLO	PDF4LHC
$t\bar{t}H$	MadGraph5_aMC@NLO (v.2.2.3) [30]	NLO	CT10nlo [31]
$b\bar{b}H$	MadGraph5_aMC@NLO (v.2.3.3) [30,32]	NLO	NNPDF23 [33]

Table 2
Cross-section predictions used to normalize the MC samples, the accuracy of the calculations (in QCD if not noted otherwise), and the composition of the production modes in the SM.

Process	Accuracy	Fraction [%]
ggF	N^3LO, NLO EW corrections [37–50]	87.4
VBF	NLO, NLO EW corrections [51–53] with approximate NNLO QCD corrections [54]	6.8
VH	NNLO [55,56], NLO EW corrections [57]	4.1
$t\bar{t}H$	NLO, NLO EW corrections [58–61]	0.9
$b\bar{b}H$	five-flavour: NNLO, four-flavour: NLO [62]	0.9

from the fiducial to the total phase space contained in the bin of interest.

Predicted branching ratios and production cross sections are obtained for $m_H = 125.09$ GeV [15], as described in Section 2. The number of signal events in each bin of a probed observable is extracted in the $H \to \gamma\gamma$ and $H \to ZZ^* \to 4\ell$ channels from fits to the $m_{\gamma\gamma}$ and $m_{4\ell}$ invariant mass distributions, respectively. The signal extraction and the correction factors are discussed in detail in Refs. [11,12]. The correction factors are obtained from simulated events, assuming SM Higgs boson production. In order to harmonize the published $H \to \gamma\gamma$ fiducial measurement [11] with the $H \to ZZ^* \to 4\ell$ analysis [12], adjustments were made to the bin boundaries and the uncertainties of the correction factors due to the fractions of different Higgs boson production processes in the $H \to \gamma\gamma$ decay channel. To extrapolate to the total phase space, acceptance factors and uncertainties are calculated for the combination, as discussed in Section 3. Section 4 presents the combination methodology. The results are discussed in Section 5.

2. Higgs boson Monte Carlo samples, cross sections and branching fractions

Predictions of SM Higgs boson production are used in the calculation of the correction and acceptance factors, and are compared to the measured cross sections. The Monte Carlo (MC) event generators that were used to simulate gluon–gluon fusion (ggF), vector-boson fusion (VBF), associated Higgs boson production (VH, $V = W, Z$), and Higgs boson production in association with a heavy-quark pair ($t\bar{t}H$, $b\bar{b}H$) are listed in Table 1. The accuracy of the calculations and the PDF sets used are also given, with the abbreviations NLO for next-to-leading order, NNLO for next-to-next-to-leading order, and NNLL for next-to-next-to-leading logarithm. For ggF, VBF, VH, $b\bar{b}H$ in both decay channels and $t\bar{t}H$ in the $H \to \gamma\gamma$ decay channel, Pythia8 [16,17] was used for the decay, parton shower, hadronization and multiple parton interactions. For $t\bar{t}H$ in the $H \to ZZ^* \to 4\ell$ decay channel, Herwig++ [18,19] was used.

The samples are normalized to the cross-section predictions taken from Refs. [14,34–36]. These predictions were obtained assuming a Higgs boson mass of 125.09 GeV [15] to calculate cross sections and branching ratios. Details are given in Table 2, including the accuracy of the calculations, and the composition of the production modes in the SM. N^3LO is the abbreviation for next-to-next-to-next-to-leading order, and EW stands for electroweak.

In addition to the NNLOPS sample (see Table 1) scaled to the N^3LO cross section with a K-factor of 1.1, further SM ggF predictions are compared with the measurements. If not mentioned otherwise, the cross sections predicted by the respective calculations are used. For the comparison with data, the non-ggF Higgs boson production processes are added using the samples and cross sections described above.

- The p_T^H distribution is compared with the predictions from HRes [63,64], RaDISH + NNLOJET [65], and MadGraph5_aMC@NLO. HRes includes resummation to NNLL and computes fixed-order cross sections for ggF Higgs boson production up to NNLO in QCD. It describes the p_T^H distribution at NLO. Finite t-, b-, and c-quark masses are included at NLO accuracy. The RaDISH + NNLOJET prediction includes resummation to NNLL and matching to the one-jet NNLO differential spectrum from NNLOJET [66,67]. It includes corrections from the finite t- and b-quark masses. The predictions from MadGraph5_aMC@NLO are scaled to the N^3LO cross section with a K-factor of 1.47. This generator provides NLO accuracy in QCD for zero, one, and two additional jets, merged with the FxFx scheme [68] and includes the finite top quark mass effects [30,69,70].
- The $\lvert y^H \rvert$ measurement is compared with predictions from MadGraph5_aMC@NLO merged with the FxFx scheme and SCETlib + MCFM8 [71,72], which achieves NNLO + NNLL'_{φ} accuracy[1] by applying a resummation of the virtual corrections to the gluon form factor. The underlying NNLO predictions are obtained using MCFM8 with zero-jettiness subtractions [73, 74].
- The p_T^{j1} measurement is compared with SCETlib, with NNLL′ + NNLO_0 accuracy[2] [72,75].
- Multiple predictions exist for different bins of the N_{jets} distribution. Considered here are the STWZ-BLPTW prediction [14, 75,76], which includes NNLL′+NNLO resummation for the p_T of the leading jet, combined with a NLL′+NLO resummation for the subleading jet, and the JVE-N^3LO prediction [77], which includes NNLL resummation of the p_T of the leading jet with small-R resummation and is matched to the N^3LO total cross section. In addition, predictions from MadGraph5_aMC@NLO, are compared with the full N_{jets} distribution.

For ggF, VBF and VH, the PDF4LHC set is varied according to its eigenvectors [25], and the envelope of the variations is used as the systematic uncertainty. The effect of PDF uncertainties on $t\bar{t}H$ and $b\bar{b}H$ is negligible and not included. The renormalization and fac-

[1] The prime indicates that important parts of the N^3LL (next-to-next-to-next-to-leading logarithm) contribution are included along with the full NNLL corrections and the subscript φ indicates that resummation is applied to the gluon form factor.
[2] NNLO_0 refers to the NNLO corrections relative to the LO $gg \to H$ process with 0 additional partons.

torization scales are varied by factors of 2.0 and 0.5. For NNLOPS, instead of the internal scale uncertainties, the same scheme as in Refs. [11,12,78] is used: four parameters account for uncertainties in the cross sections for events with different jet multiplicities [14, 75,76,79], and three parameters account for the uncertainties in the modelling of the p_T^H distributions.

The predicted Higgs boson decay branching ratios are (0.227 $\pm$ 0.007)% and (0.0125 $\pm$ 0.0003)% for the $H \to \gamma\gamma$ and $H \to ZZ^* \to 4\ell$ decays, respectively [14]. Both branching ratio calculations include the complete NLO QCD and EW corrections. For $H \to ZZ^* \to 4\ell$, the interference effects between identical final-state fermion pairs are included. The correlations of the branching ratio uncertainties and the dependence of the predicted branching ratios on the Higgs boson mass are taken into account in the combination. For the $H \to ZZ^* \to 4\ell$ decay channel, which has the larger dependence, this corresponds to a relative variation of $\sim$2% in the branching ratio when varying the assumed Higgs boson mass by $\pm$0.24 GeV [15].

3. Acceptance correction

The acceptance factors that extrapolate at particle-level from the $H \to \gamma\gamma$ and $H \to ZZ^* \to 4\ell$ fiducial phase space to the full phase space are estimated using the MC samples and cross sections described in Section 2. Their evaluation assumes SM Higgs boson production fractions and a Higgs boson mass of 125 GeV; the 90 MeV difference from 125.09 GeV has negligible impact on the Higgs boson kinematics and is covered by the systematic uncertainty from the Higgs boson mass measurement.

In the $H \to \gamma\gamma$ fiducial phase space [11], the selected events have two photons with pseudorapidity[3] $|\eta| < 1.37$ or $1.52 < |\eta| < 2.37$ and $p_T{}^{\gamma_1} > 0.35 m_{\gamma\gamma}$, $p_T{}^{\gamma_2} > 0.25 m_{\gamma\gamma}$, where $p_T{}^{\gamma_{1(2)}}$ refers to the transverse momentum of the (sub)leading photon and $m_{\gamma\gamma}$ is the invariant mass of the two photons. The photons are required to be isolated: the p_T of the system of charged generator-level particles within $\Delta R = 0.2$ of the photon is required to be less than 0.05 times the p_T of the photon. In the $H \to ZZ^* \to 4\ell$ fiducial phase space [12], the selected events have four muons, four electrons, or two electrons and two muons. The three leading leptons are required to have $p_T >$ 20, 15, 10 GeV. The lowest-p_T muon (electron) has to fulfil $p_T > 5$ (7) GeV. The muons have to be within $|\eta| < 2.7$ and the electrons within $|\eta| < 2.47$. Following the selection of events in data, requirements are placed on the masses of the two same-flavour opposite-charge pairs, on the ΔR of any two leptons, and the invariant mass of the four-lepton system, 115 GeV $< m_{4\ell} <$ 130 GeV.

In the total phase space, the quantities p_T^H and $|y^H|$ are computed directly from the simulated Higgs boson momentum instead of its decay products, as in the fiducial analyses. Simulated particle-level jets are built from all particles with $c\tau > 10$ mm excluding neutrinos, electrons and muons that do not originate from hadron decays. Photons are excluded from jet finding if they originate directly from the Higgs boson decay or are radiated off leptons from the Higgs boson decay. Jets are reconstructed using the anti-k_t algorithm [80] with a radius parameter $R = 0.4$, and are required to have $p_T > 30$ GeV.

Theory uncertainties in the signal acceptance related to the PDF, higher-order corrections, and the parton shower are considered for the acceptance factors and are correlated between the two channels. Uncertainties due to the PDF and scales are estimated as described in Section 2. Uncertainties due to the parton shower are evaluated by comparing the ggF default showering Pythia8 with Herwig7. The uncertainty is derived from the full difference between the two cases. The Higgs boson mass is varied within the uncertainty of the ATLAS–CMS combined measurement [15]. To account for model dependence, the fractions of production modes are varied within the uncertainties from the dedicated measurements by the ATLAS and CMS collaborations [81]. For $t\bar{t}H$, the 13 TeV ATLAS results are used [82]. The $b\bar{b}H$ cross section is varied within the uncertainties due to the PDF and higher-order corrections [14]. The total systematic uncertainties of the acceptance factors range between 0.4% and 5%, depending on the observable and bin. The parton shower uncertainty dominates.

The inclusive acceptance factors are 50% for the $H \to \gamma\gamma$ channel and 42% for the $H \to ZZ^* \to 4\ell$ channel (relative to the full phase space of $H \to ZZ^* \to 2\ell 2\ell'$, where $\ell, \ell' = e$ or μ). The acceptance is lower for $H \to ZZ^* \to 4\ell$ than for $H \to \gamma\gamma$ since it is less likely for four leptons to fulfil the fiducial requirements. Fig. 1 shows the acceptance factors used for the differential observables and their systematic uncertainties. The fiducial acceptance falls off steeply as the Higgs boson rapidity increases, as both fiducial definitions include pseudorapidity requirements on the Higgs boson decay products. The fiducial acceptance in the $H \to \gamma\gamma$ channel as a function of p_T^H is shaped by the p_T selection criteria on the photons.

4. Statistical procedure

The combined measurement is based on maximizing the profile-likelihood ratio [83]:

$$\Lambda(\boldsymbol{\sigma}) = \frac{\mathcal{L}(\boldsymbol{\sigma}, \hat{\hat{\boldsymbol{\theta}}}(\boldsymbol{\sigma}))}{\mathcal{L}(\hat{\boldsymbol{\sigma}}, \hat{\boldsymbol{\theta}})}.$$

Here $\boldsymbol{\sigma}$ are the parameters of interest, $\boldsymbol{\theta}$ are the nuisance parameters, and $\mathcal{L}$ represents the likelihood function. The $\hat{\boldsymbol{\sigma}}$ and $\hat{\boldsymbol{\theta}}$ terms denote the unconditional maximum-likelihood estimate of the parameters, while $\hat{\hat{\boldsymbol{\theta}}}(\boldsymbol{\sigma})$ is the conditional maximum-likelihood estimate for given parameter values.

The likelihood function $\mathcal{L}$ includes the signal extraction, the correction to particle level, and the extrapolation to the total phase space in each channel. Therefore, the total cross section as well as the cross sections in different bins for each observable can be derived directly as parameters of interest $\boldsymbol{\sigma}$ based on the combined data set from the $H \to \gamma\gamma$ and $H \to ZZ^* \to 4\ell$ channels.

The distribution shape and normalization systematic uncertainties of all components are included in the likelihood function as nuisance parameters $\boldsymbol{\theta}$ with constraints from subsidiary measurements. This allows the uncertainties to be correlated between bins, decay channels, and correction and acceptance factors. The uncertainty components of the predicted branching ratios are correlated between the decay channels, as well as the uncertainties in the acceptance and correction factors due to production mode variations, PDF and higher-order corrections, and the parton shower. The uncertainty in the Higgs boson mass, including its effect on the predicted branching ratio, is also correlated between channels. Experimental uncertainties in the correction factors and the signal extraction in the $H \to ZZ^* \to 4\ell$ decay channel, like the energy scale and resolution of electrons, photons, and jets, and in the luminosity measurement and pileup modelling are also correlated.

[3] ATLAS uses a right-handed coordinate system with its origin at the nominal interaction point (IP) in the centre of the detector and the z-axis along the beam pipe. The x-axis points from the IP to the centre of the LHC ring, and the y-axis points upwards. Cylindrical coordinates (r, ϕ) are used in the transverse plane, ϕ being the azimuthal angle around the z-axis. The pseudorapidity is defined in terms of the polar angle θ as $\eta = -\ln\tan(\theta/2)$. Angular distance is measured in units of $\Delta R \equiv \sqrt{(\Delta\eta)^2 + (\Delta\phi)^2}$.

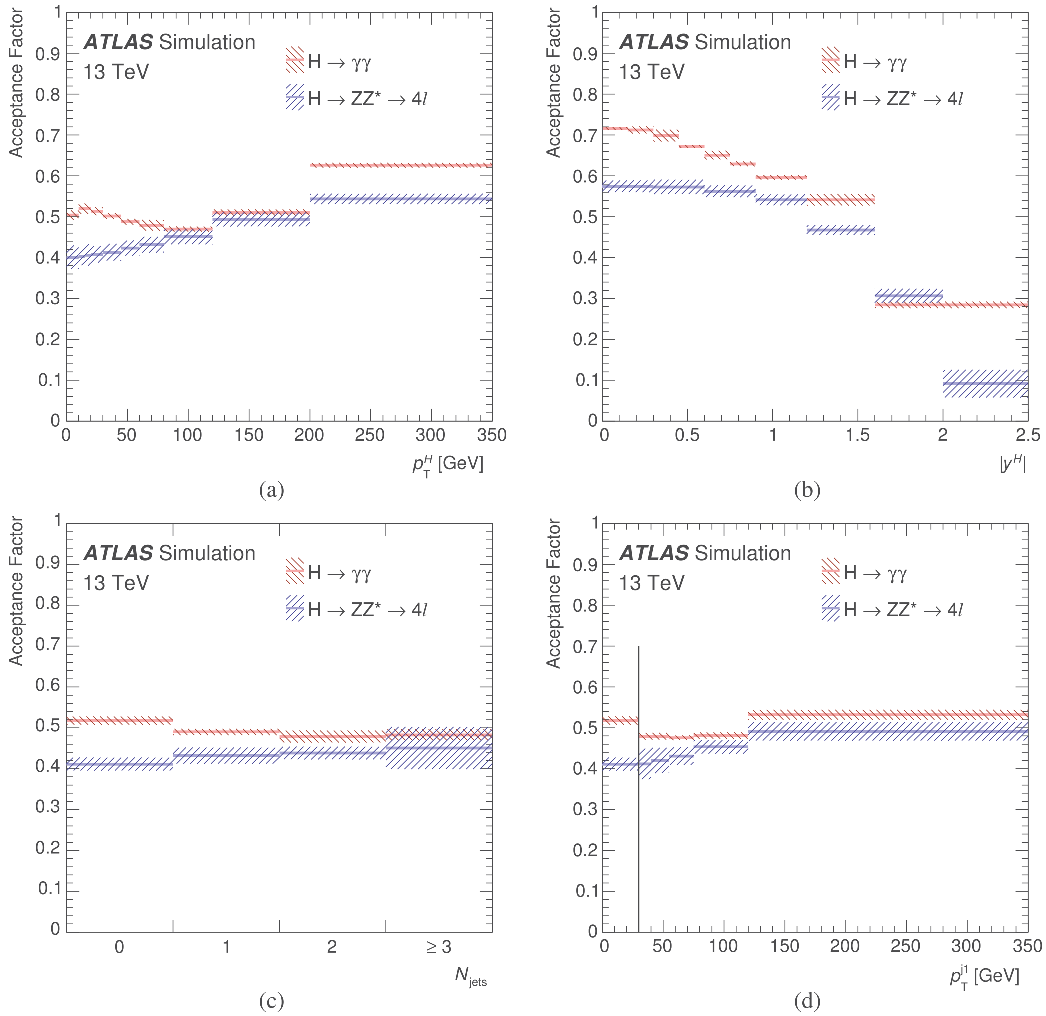

Fig. 1. Acceptance factors for the extrapolation from the fiducial to the total phase space for the $H \to \gamma\gamma$ decay channel (red) and the $H \to ZZ^* \to 4\ell$ decay channel (blue), for (a) Higgs boson transverse momentum p_T^H, (b) Higgs boson rapidity $|y^H|$, (c) number of jets N_{jets} with $p_T > 30$ GeV, and (d) transverse momentum of the leading jet p_T^{j1}, including systematic uncertainties. The first bin in the p_T^{j1} distribution corresponds to the 0-jet bin in the N_{jets} distribution, as indicated by the black vertical line. (For interpretation of the colours in the figure(s), the reader is referred to the web version of this article.)

The bin boundaries of all probed observables are consistent between the $H \to \gamma\gamma$ and the $H \to ZZ^* \to 4\ell$ analyses [11,12]. Where one bin in one of the measurements corresponds to two bins in the other, the wider bin size is used. The sum of the cross sections in the finer bins is considered as the parameter of interest in these cases, and an additional unconstrained nuisance parameter that floats in the fit describes the difference between the merged bins. The normalization and shape uncertainties of the $H \to \gamma\gamma$ background estimate [11] are fit to the data as nuisance parameters without any initial constraint.

The test statistic $-2\ln\Lambda$ is assumed to follow a χ^2 distribution for constructing confidence intervals [83]. This asymptotic assumption was tested with pseudo-experiments for bins with low numbers of events and found to be appropriate.

The level of agreement between the two channels in the total phase space is evaluated by using a profiled likelihood as a function of the difference of the cross sections in each bin i, $\sigma^i_{\gamma\gamma} - \sigma^i_{4\ell}$. The number of degrees of freedom is the same as the number of bins in the tested distribution. The probability that a measured differential cross section is compatible with a theoretical prediction is found by computing a p-value based on the difference between the value of $-2\ln\Lambda$ at the unconditional maximum-likelihood estimate and the value obtained by fixing the cross sections in all bins to the ones predicted by the theory. The uncertainties in the theoretical predictions are ignored when calculating the p-values. Including these uncertainties would increase the p-values.

5. Results

The total cross section is measured to be $47.9^{+9.1}_{-8.6}$ pb in the $H \to \gamma\gamma$ decay channel and 68^{+11}_{-10} pb in the $H \to ZZ^* \to 4\ell$ channel. The result of the combined measurement is $57.0^{+7.2}_{-6.8}$ ($^{+6.0}_{-5.9}$ (stat.) $^{+4.0}_{-3.3}$ (syst.)) pb, in agreement with the SM prediction of 55.6 ± 2.5 pb [14]. The results from the individual decay channels are compatible, with a p-value of 14%.

Fig. 2 shows the differential cross sections in the total phase space measured in the $H \to \gamma\gamma$ and $H \to ZZ^* \to 4\ell$ decay channels as well as the combined measurement as a function of p_T^H, $|y^H|$, N_{jets}, and p_T^{j1}. Different SM predictions are overlaid. The uncertainties in the MADGRAPH5_AMC@NLO distribution are larger than for the other predictions, as this prediction is at NLO accuracy only.

For all differential observables and bins, the measurement is dominated by statistical uncertainties, which vary between 20% and 30%. Significant uncertainties affecting all observables, includ-

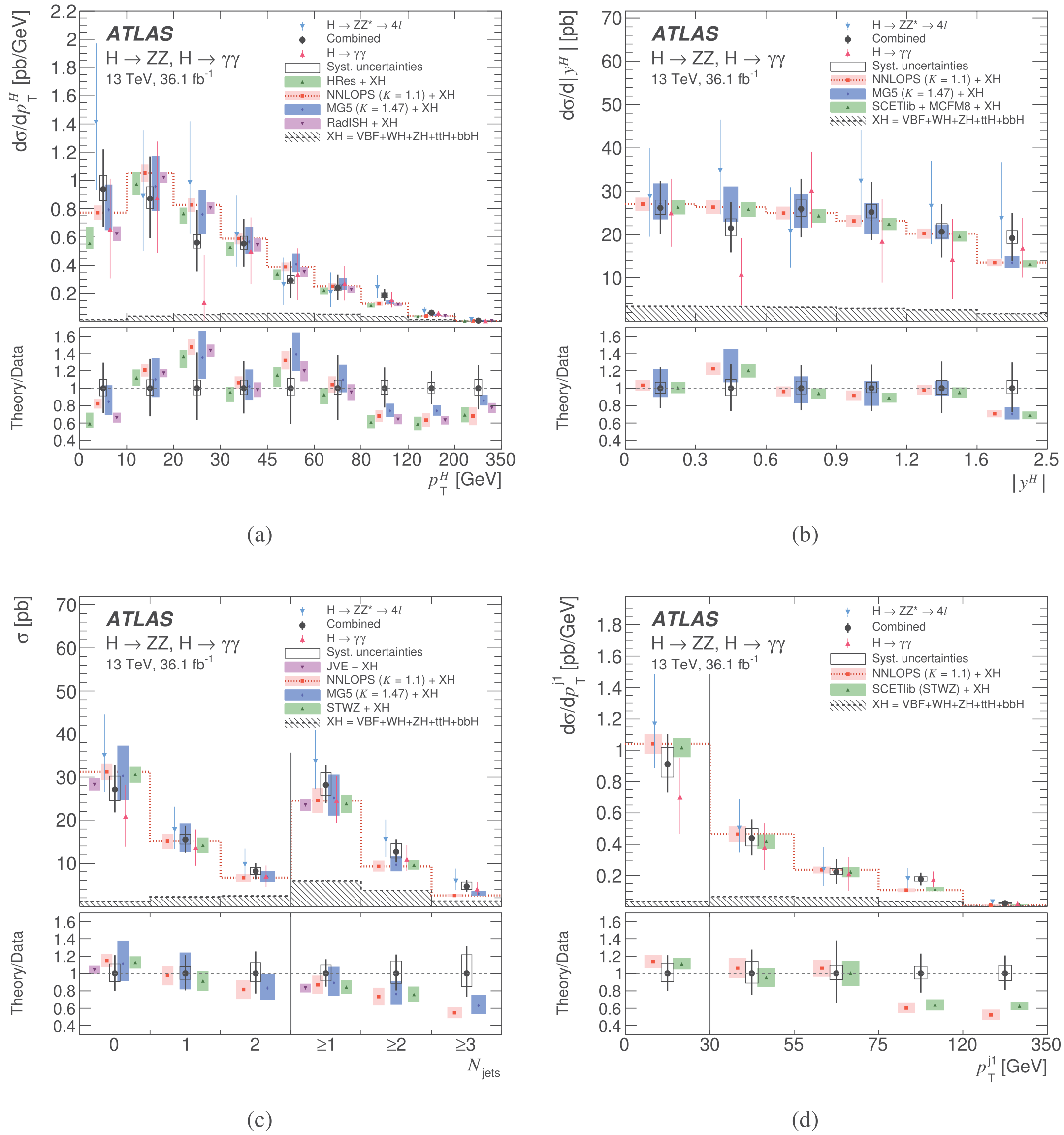

Fig. 2. Differential cross sections in the full phase space measured with the $H \to \gamma\gamma$ (red upward triangle) and $H \to ZZ^* \to 4\ell$ (blue downward triangle) decay channels, as well as the combined measurement (black circle) for (a) Higgs boson transverse momentum p_T^H, (b) Higgs boson rapidity $|y^H|$, (c) number of jets N_{jets} with $p_T > 30$ GeV, and (d) the transverse momentum of the leading jet p_T^{j1}. The first bin in the p_T^{j1} distribution corresponds to the 0-jet bin in the N_{jets} distribution, as indicated by the black vertical line. Different SM predictions are overlaid, their bands indicating the PDF uncertainties as well as uncertainties due to missing higher-order corrections. The ordering of the predictions is the same in the legend as in the figure. Predictions for the other production processes XH are added to the ggF predictions, and also shown separately as a shaded area. The dotted red line corresponds to the central value of the NNLOPS ggF prediction, scaled to the total N^{3}LO cross section by the given K-factor, and added to the XH prediction. The uncertainties due to higher orders in the NNLOPS prediction are obtained as in Refs. [11,12,78]. The MADGRAPH5_AMC@NLO prediction is scaled to the total N^{3}LO cross section by the given K-factor. For better visibility, all bins are shown as having the same size, independent of their numerical width. The panel on the bottom shows the ratio of the predictions to the combined measurement. The total uncertainties of the combined measurement are indicated by the black error bars, the systematic uncertainties by the black open boxes.

ing the total cross section, include the uncertainty in the 2015 and 2016 integrated luminosity, which is 3.2% [84], affecting the signal and simulated background estimates in the $H \to ZZ^* \to 4\ell$ decay channel, with an impact of about 4% on the measurement, and the background estimate in the $H \to \gamma\gamma$ signal extraction [11], typically 2–6%. For N_{jets} and p_T^{j1}, the uncertainties in the reconstruction of the jet energy scale and resolution are important as well, typically 3–6% (>10% for $N_{\text{jets}} \geq 3$) [85].

The level of agreement between the two channels in the total phase space is quantified by the corresponding p-values: 58% for p_T^H, 40% for $|y^H|$, 53% for N_{jets} and 67% for p_T^{j1}.

Table 3 shows the p-values indicating reasonable agreement between the probed SM predictions and the measurement. The relatively low p-value for HRES can be explained by the lower computed total cross section, as this prediction is at NNLO + NNLL accuracy. The lower p-values for p_T^{j1} reflect the lower predictions compared to the measurement for high jet p_T. Compatibility checks of individual bins indicate less than 3σ local discrepancy.

6. Conclusion

A combined measurement of the total and differential cross sections in the $H \to \gamma\gamma$ and $H \to ZZ^* \to 4\ell$ decay channels was performed, using 36.1 fb^{-1} of 13 TeV proton–proton collision data produced by the LHC and recorded by the ATLAS detector in 2015 and 2016. Good agreement is observed when comparing the re-

Table 3
p-values in percent indicating the probabilities that the measured differential cross sections are compatible with various SM ggF predictions. The NNLOPS and MADGRAPH5_AMC@NLO predictions are scaled to the total N^3LO cross section by the given K-factors. The non-ggF predictions are added, as discussed in Section 2. The uncertainties in the theoretical predictions are ignored when calculating the p-values.

p-values [%]	p_T^H	$\|y^H\|$	N_{jets}	p_T^{j1}
NNLOPS ($K = 1.1$)	29	92	43	6
HRES	16	–	–	–
RADISH + NNLOJET	30	–	–	–
SCETLIB	–	91	–	23
MADGRAPH5_AMC@NLO ($K = 1.47$)	77	91	65	–

sults from the two channels, extrapolated to a common phase space. The total Higgs boson production cross section is measured to be $57.0^{+6.0}_{-5.9}$ (stat.) $^{+4.0}_{-3.3}$ (syst.) pb, in agreement with the Standard Model prediction. Differential cross-section measurements are presented for the Higgs boson transverse momentum distribution, Higgs boson rapidity, number of jets produced together with the Higgs boson, and the transverse momentum of the leading jet. The larger data set and the combination of the two decay channels give measurement uncertainties that are significantly smaller than in previous results. The combined results agree with Standard Model predictions.

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