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Differential cross section measurements in $H \to \gamma\gamma$ with the ATLAS detector at the LHC

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This work presents differential cross section measurements of the Higgs boson, performed in the diphoton decay channel. The dataset used corresponds to 20.3 fb^{-1} of proton-proton collisions at $\sqrt{s} = 8$ TeV, produced by the LHC and collected by the ATLAS detector in 2012. With its high signal selection efficiency the diphoton decay channel is well suited to probe the underlying kinematic properties of the signal production and decay. Measurements are made within the geometric acceptance of the detector, for observables of the two photons from the Higgs boson decay, and for jets produced in association with it. These measurements are corrected for experimental acceptance and resolution. Results are compared to theoretical predictions at the particle level.

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The particle discovered in 2012 by the ATLAS and CMS collaborations has been shown to conform to the Standard Model (SM) predictions for the couplings and spin properties of the Higgs boson. [2, 3] This work extends those results by presenting differential cross sections of the Higgs boson, measured in the diphoton decay channel. This channel is well-suited to these measurements, by its high selection efficiency and straightforward signal extraction.

Eight distributions were measured, which present the full kinematics of the Higgs boson, and which are sensitive to the relative rates of its different production modes, to its spin and CP eigenvalues, to QCD radiation in gluon fusion production, and to new phenomena. The extracted variables are: the transverse momentum of the Higgs boson, $p_{\mathrm{T}}^{\gamma\gamma}$; its rapidity, $|y^{\gamma\gamma}|$; the helicity angle in the Collins-Soper frame, $|\cos\theta^*|$; the multiplicity of jets, N_{jets}; the ratios of 'inclusive' and 'exclusive' cross sections of N_{jets}, $\sigma_{N_{\mathrm{jets}}=i}/\sigma_{N_{\mathrm{jets}}\geq i}$; the transverse momentum of the leading jet, $p_{\mathrm{T}}^{j_1}$; the azimuthal separation between the two leading jets, $\Delta\phi_{jj}$; and the transverse momentum of the entire Higgs and dijet system, $p_{\mathrm{T}}^{\gamma\gamma jj}$. The full presentation of these results is contained in Ref. [1].

Methods

The event selection follows that used for previous analyses of the spin of the Higgs boson, in the diphoton channel. [2] A total of 94135 events were selected by requiring two high-p_T photon candidates within the geometric acceptance of the ATLAS detector, along with quality cuts designed to separate electromagnetic objects from the large QCD background. The selected sample is 75% pure in diphoton events; the rest are photon-jet (20%), dijet and Drell-Yan ($< 5\%$).

To extract the differential cross sections, the dataset is binned in each of the measured observables, and signal plus background fits are performed to the invariant mass spectrum, for each bin. The yields thus obtained are corrected for detector response, by multiplying them by the ratio of the number of events generated within the fiducial region (p_Ts, geometric acceptance, and particle isolation), to the number of fully-simulated and selected events, measured in SM Monte Carlo.

Results and Conclusions

The unfolded results are compared to SM Higgs boson Monte Carlo, and shown in Fig. 1. The consistency of the data with the SM expectation is evaluated as the probabilities of the χ^2 tests, taking into account all correlations between bins of the observables (Table 1). Due primarily to the large statistical uncertainties, this compatibility is found to be quite good, for all distributions.

References

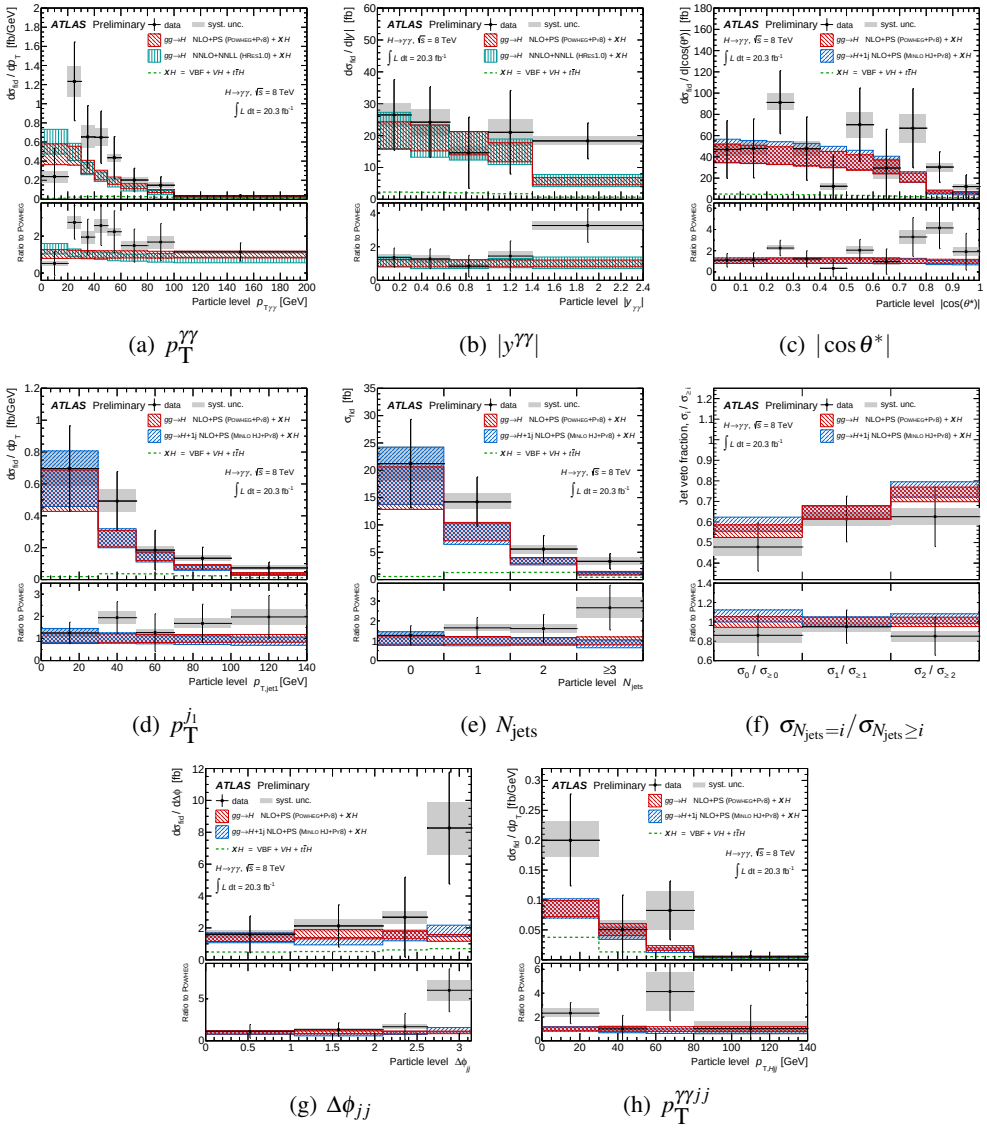
[1] The ATLAS Collaboration. *Differential cross sections of the Higgs boson measured in the diphoton decay channel using 8 TeV pp collisions.* ATLAS-CONF-2013-072. `http://cds.cern.ch/record/1562925/`

[2] The ATLAS Collaboration. *Evidence for the spin-0 nature of the Higgs boson using ATLAS data.* 2013. [`hep-ex/1307.1427`] Submitted to Physics Letters B.

[3] The ATLAS Collaboration. *Measurements of Higgs boson production and couplings in diboson final states with the ATLAS detector at the LHC.* 2013. [`hep-ex/1307.1427`] Submitted to Physics Letters B.

	N_{jets}	$p_{\text{T}}^{\gamma\gamma}$	$\lvert y^{\gamma\gamma}\rvert$	$\lvert\cos\theta^*\rvert$	$p_{\text{T}}^{j_1}$	$\Delta\phi_{jj}$	$p_{\text{T}}^{\gamma\gamma jj}$
POWHEG	0.54	0.55	0.38	0.69	0.79	0.42	0.50
MINLO	0.44	–	–	0.67	0.73	0.45	0.49
HRES 1.0	–	0.39	0.44	–	–	–	–

Table 1: Displayed are the probabilities from χ^2 tests for the agreement between the unfolded observation and the theoretical predictions, calculated with the full covariance between bins of the observables.



(a) $p_{\text{T}}^{\gamma\gamma}$ (b) $|y^{\gamma\gamma}|$ (c) $|\cos\theta^*|$

(d) $p_{\text{T}}^{j_1}$ (e) N_{jets} (f) $\sigma_{N_{\text{jets}}=i}/\sigma_{N_{\text{jets}}\geq i}$

(g) $\Delta\phi_{jj}$ (h) $p_{\text{T}}^{\gamma\gamma jj}$

Figure 1: Observed differential cross sections of the Higgs bosons decaying into two isolated photons. Systematic uncertainties are presented in grey, and the black bars represent the quadratic sum of statistical and systematic errors. The hatched histograms present theoretical predictions for the Standard Model at $\sqrt{s} = 8$ TeV and $m_H = 126.8$ GeV. Their width represents the theory uncertainties from missing higher order corrections, the PDF set used, the simulation of the underlying event, and the $H \to \gamma\gamma$ branching fract ion. The sum of VBF with WH, ZH, and $t\bar{t}H$ is denoted XH. These are added to the simulated ggH predictions from POWHEG, MINLO, and HRES. [1]