PROCEEDINGS OF SCIENCE

Measurement of production cross sections and coupling properties of the Higgs boson in decays to two photons using the ATLAS detector

Liza Mijović* on behalf of the ATLAS Collaboration
SUPA - School of Physics and Astronomy, University of Edinburgh, United Kingdom
E-mail: liza.mijovic@cern.ch

This report summarizes the results of the measurement of production cross sections and coupling properties of the Higgs boson in decays to two photons. The measurement is performed using 79.8 fb^{-1} of data from LHC proton-proton collisions at the center-of-mass energy of $\sqrt{s} = 13$ TeV recorded by the ATLAS experiment. These results have improved precision compared to the results previously reported by ATLAS which used 36 fb^{-1} of data. Differential cross section measurements targeting gluon-gluon fusion production in association with b-jets have also been added.

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1. Introduction

The results of the measurement of production cross sections and coupling properties of the Higgs boson (H) in decays to two photons ($H\to\gamma\gamma$) [1] are summarised. The measurement is performed using 79.8 fb^{-1} of the LHC proton-proton (pp) collisions data, taken at $\sqrt{s} = 13$ TeV centre-of-mass energy with the ATLAS detector [2]. These results exhibit improved precision compared to the results previously reported by ATLAS in Ref. [3] which used 36 fb^{-1} of data. Differential cross section measurements targeting gluon-gluon fusion production in association with b-jets have also been added.

The measurements in the $H\to\gamma\gamma$ decay channel capitalise on the high resolution of the ATLAS electromagnetic calorimeter and excellent photon reconstruction and identification efficiency. These features enable the $H\to\gamma\gamma$ decay to be reconstructed as a narrow peak in the invariant mass distribution of the two photons ($m_{\gamma\gamma}$) as shown in Figure 1. The continuum backgrounds are estimated from the fit of a functional form to the data side-bands and the signal is extracted from the fitted signal-plus-background model.

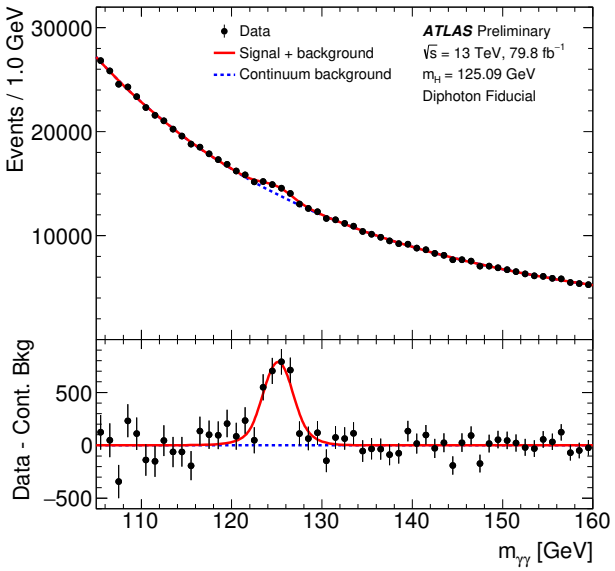


Figure 1: The diphoton invariant mass spectrum in the diphoton fiducial region [1]. The data and the fitted signal-plus-background (solid line) and background only model (dashed line) are shown.

2. Production mode cross section measurements

Production cross sections are measured in several modes: gluon-gluon fusion (ggF), vector-boson fusion (VBF), Higgs boson production in association with a vector boson (VH: sum of WH, $q\bar{q}\to$ZH, and $gg\to$ZH processes) and Higgs boson production in association with a top quark (Top: $t\bar{t}H$ or associated single top quark production tH). The measured cross sections times the $H\to\gamma\gamma$ branching ratio are shown in Figure 2, divided by the Standard Model (SM) predictions. The measurements are done for Higgs boson rapidity $|y_H| < 2.5$. All measured values are consistent

with the SM predictions. For the ggF and VBF modes the statistical uncertainty is comparable to the systematic uncertainty. The VH and Top production mode measurements are dominated by the statistical uncertainties.

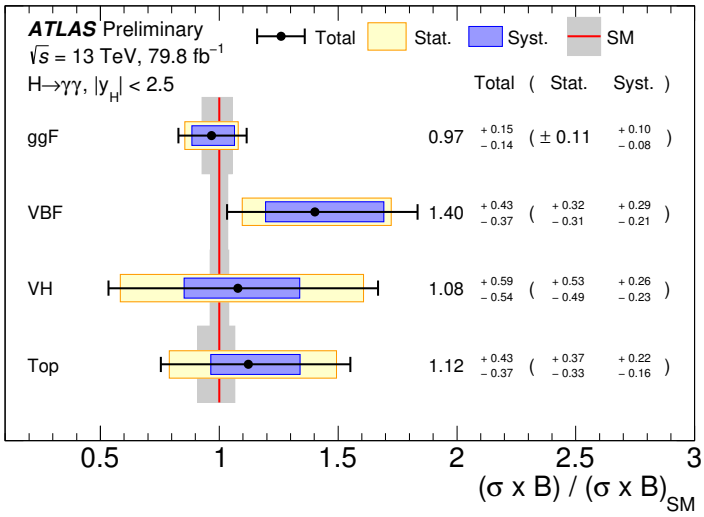


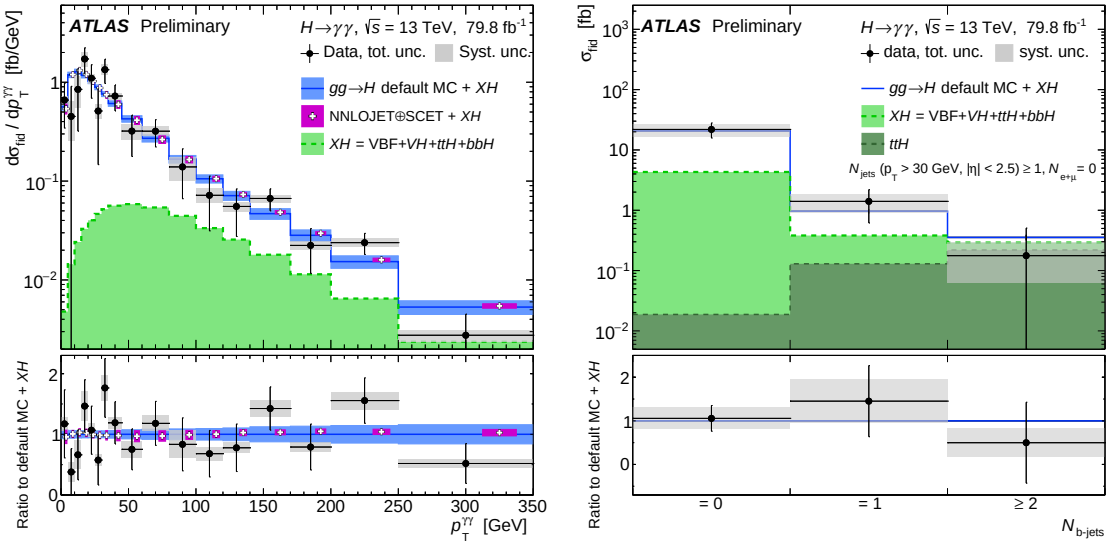
Figure 2: Cross section measurements for various production modes [1].

3. Fiducial and differential cross section measurements

The fiducial cross sections are measured within the detector acceptance, reducing extrapolation uncertainties. The two highest transverse momentum (p_{T}) photons are required to be within rapidity[1] $|\eta| < 2.37$ and outside $1.37 < |\eta| < 1.52$. The leading (sub-leading) photon must satisfy $p_{\mathrm{T}}/m_{\gamma\gamma} > 0.35(0.25)$ and isolation requirements. The measurements are unfolded to particle level, using bin-by-bin unfolding. The VBF,VH,Top and $b\bar{b}H$ production modes are commonly denoted with XH. The modeling of the XH processes is obtained from the simulation and normalised to the SM cross sections. The ggF prediction is based on POWHEG NNLOPS [4] and normalised to the theoretical calculation at N^{3}LO(QCD)+NLO(EW) order [5]. The inclusive fiducial $H\to\gamma\gamma$ cross section is measured to be $\sigma_{\mathrm{fid}} = 60.4 \pm 6.1(\mathrm{stat.}) \pm 6.0(\mathrm{exp.}) \pm 0.3(\mathrm{theo.})$ fb, consistent with the SM prediction of 63.5 ± 3.3 fb within one standard deviation.

Figure 3a shows the fiducial differential cross section measured as a function of $p_{\mathrm{T}}{}^{\gamma\gamma}$ which is found to be consistent with the SM prediction. Figure 3b shows the differential measurement as a function of the number of b-jets. The measurement is aimed at constraining the ggF production in association with b-jets (ggF+b-jets). The ggF+b-jets is an important background to processes such as $t\bar{t}H$ or di-Higgs production and has large theoretical uncertainties. The events are required to have no high-p_{T} leptons to suppress the $t\bar{t}H$ production, which nonetheless dominates the $N_{\text{b-jets}} \geq 2$ bin. The $N_{\text{b-jets}} = 1$ bin is sensitive to the associated ggF+b-jets production and is limited by the statistical uncertainty with 79.8 fb^{-1} of data.

[1] 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 upward. 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 $\eta = -\ln\tan(\theta/2)$.



(a) (b)

Figure 3: The fiducial differential cross sections measured [1] as a function of (a) $p_T{}^{\gamma\gamma}$, (b) number of b-jets $N_{\text{b-jets}}$.

4. Summary & outlook

The $H\to\gamma\gamma$ production cross section and coupling measurements at ATLAS have improved precision compared to the previous ATLAS result [3]. New differential measurements have been provided. Measurements of several quantities are limited by statistical uncertainties and will be improved with the full LHC Run2 data-set.

References

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