

Higgs boson fiducial differential cross-section measurements at ATLAS

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These proceedings report on recent results on inclusive and fiducial differential cross-section measurements at ATLAS. Most of the results are based on the full LHC Run 2 dataset at $\sqrt{s}=13$ TeV. First Higgs boson production cross-section measurements using LHC Run 3 data at $\sqrt{s}=13.6$ TeV are also presented.

*LHCP2023,
22th - 26th May 2023
Belgrade, Serbia*

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1. Introduction

These proceedings highlight recent Higgs boson cross-section measurements using the full Run 2 dataset, corresponding to 139 fb^{-1} at $\sqrt{s} = 13 \text{ TeV}$, and the Run 3 dataset from 2022 at $\sqrt{s} = 13.6 \text{ TeV}$, collected by the ATLAS [1] experiment. Fiducial differential cross-sections have been measured in several final states for observables sensitive to the Higgs boson properties, either related to the Higgs kinematics or to the jets produced in association with it. The fiducial phase space minimizes extrapolation effects and emulates detector and analysis acceptance, making it the most model-independent way to study the Higgs boson

2. Cross-section measurements in $H \rightarrow ZZ^* \rightarrow 4\ell$ and $H \rightarrow \gamma\gamma$ at $\sqrt{s} = 13 \text{ TeV}$

Thanks to their clean signatures, the $H \rightarrow ZZ^* \rightarrow 4\ell$ and $H \rightarrow \gamma\gamma$ decay channels have been used to measure fiducial inclusive and differential cross-sections for multiple observables [2–4]. The measurements have been found to be in agreement with the Standard Model (SM) predictions and have been used to set constraints on possible Beyond the Standard Model (BSM) effects. Figure 1(a) shows the $\Delta\phi_{jj}$ differential cross-section measured in the $H \rightarrow \gamma\gamma$ VBF-enhanced fiducial region, while Figure 1(b) shows the double-differential cross-section for m_{jj} versus $\Delta\eta_{jj}$ in the $H \rightarrow ZZ^* \rightarrow 4\ell$ VBF-enriched fiducial region. The differential cross-sections measured in

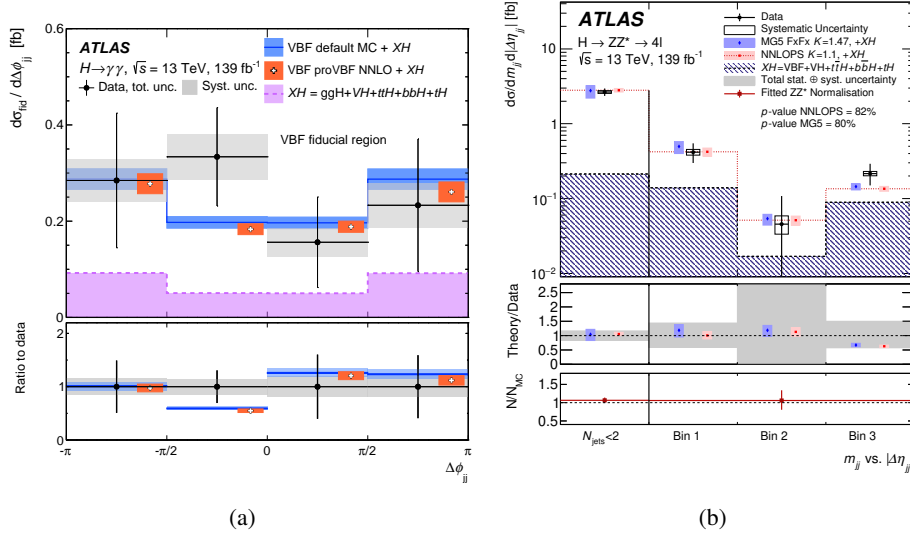


Figure 1: (a) Particle-level differential cross-sections in $H \rightarrow \gamma\gamma$ for $\Delta\phi_{jj}$ in the VBF-enhanced fiducial region. [3]. (b) Results for the $H \rightarrow ZZ^* \rightarrow 4\ell$ VBF-enriched fiducial cross-section measurement extracted from the double-differential fiducial cross-section for m_{jj} versus $\Delta\eta_{jj}$ [4].

$H \rightarrow ZZ^* \rightarrow 4\ell$ and $H \rightarrow \gamma\gamma$ have also been extrapolated to the full phase space and combined to benefit from reduced statistical uncertainties, albeit at the cost of introducing (small) additional model-dependent uncertainties [5]. Figure 2 shows the measured p_{T}^H and N_{jets} differential cross-sections in the $H \rightarrow ZZ^* \rightarrow 4\ell$ and $H \rightarrow \gamma\gamma$ decay channels, as well as their combination. Good agreement with the SM prediction is observed.

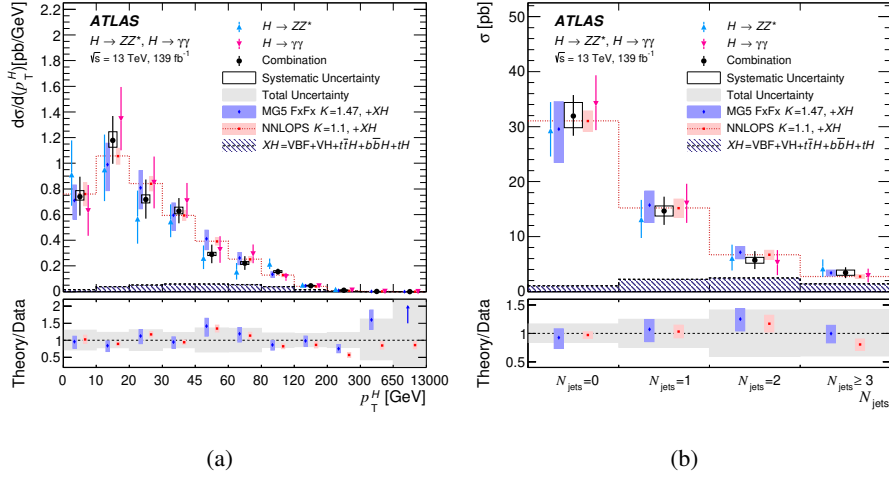


Figure 2: Higgs boson p_T^H (a) and N_{jets} (b) in the $H \rightarrow ZZ^* \rightarrow 4\ell$ and $H \rightarrow \gamma\gamma$ decay channels, as well as the combination, compared with two SM predictions, [5].

3. First cross-section measurements at $\sqrt{s} = 13.6$ TeV

ATLAS measured the inclusive and fiducial Higgs boson production cross-sections in the $H \rightarrow ZZ^* \rightarrow 4\ell$ and $H \rightarrow \gamma\gamma$ channels using approximately 31 fb^{-1} of pp collision data at $\sqrt{s} = 13.6$ TeV. Figure 3(a) shows the measured $m_{4\ell}$ distribution. The total Higgs boson production cross-section at $\sqrt{s} = 13.6$ TeV is measured to be 46 ± 12 pb for the $H \rightarrow ZZ^* \rightarrow 4\ell$ channel and 67^{+12}_{-11} pb for the $H \rightarrow \gamma\gamma$ channel. The two measurements are compatible with a p -value of 20%. Results of the measurements and the corresponding Standard Model predictions are shown in Figure 3(b). From the combination of the two measurements, the total cross-section at

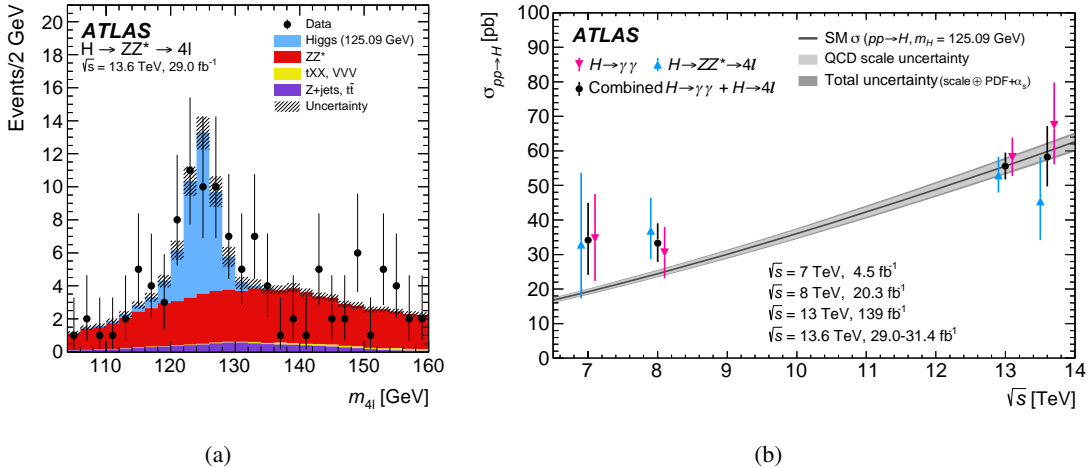


Figure 3: (a) The observed and expected inclusive $m_{4\ell}$ distribution [6]. (b) The observed total cross-section for each centre-of-mass energy from ATLAS Run 1, Run 2, and Run 3. The SM predictions and their uncertainties are shown as a function of centre-of-mass energy [6].

$\sqrt{s} = 13.6$ TeV is found to be $\sigma = 58.2 \pm 8.7$ pb. All measurements are in good agreement with the Standard Model prediction of 59.9 ± 2.6 pb.

4. Fiducial and differential cross-section in $H \rightarrow WW^* \rightarrow e\nu\mu\nu$

Despite the missing information from the neutrinos in the final state and thanks to the relatively high branching ratio, it is also possible to measure differential cross-sections in the $H \rightarrow WW^* \rightarrow e\nu\mu\nu$ final state. These measurements are performed separately for ggF [7] and VBF production [8]. Figure 4(a) shows the measured differential cross-section in the fiducial ggF phase space as a function of p_T^H , while Figure 4(b) displays the measured fiducial cross-section in the VBF phase space. In general, good agreement with the SM prediction is found.

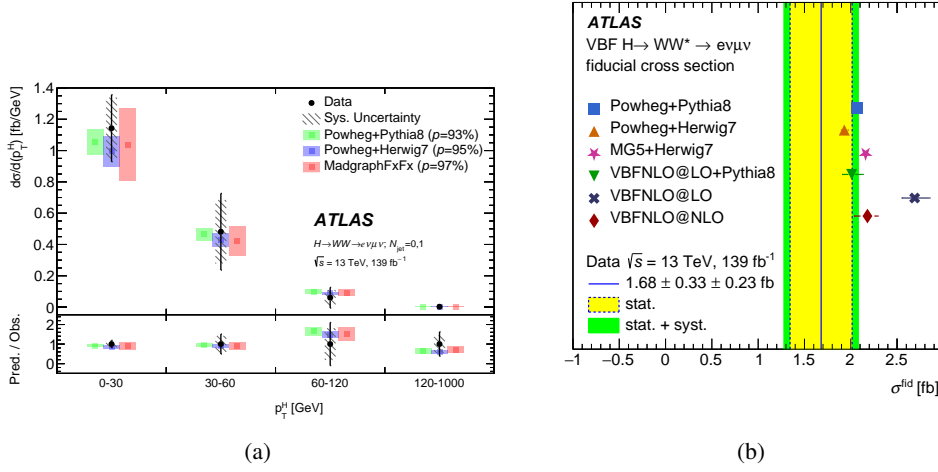


Figure 4: (a) The measured differential cross-sections as function of p_T^H in the ggF fiducial phase space compared with the theoretical predictions [7]. (b) The measured fiducial cross-section in comparison with the theoretical predictions in the VBF fiducial phase space [8].

5. Conclusions

LHC Run 2 data have already been extensively utilized to contribute to the extended ATLAS Higgs boson physics program. Numerous measurements have been published using the full Run 2 statistics, including fiducial differential cross-sections measured in several decay modes. The Standard Model predictions have been tested against the unfolded data in multiple observables, and the results are found to be compatible with SM predictions, with statistical uncertainties still dominating the measurements. The LHC began its Run 3, reaching an unprecedented center-of-mass energy of $\sqrt{s} = 13.6$ TeV. ATLAS measured the first fiducial and inclusive cross-sections in $H \rightarrow \gamma\gamma$ and $H \rightarrow ZZ^* \rightarrow 4\ell$, as well as their combination. By the end of Run 3, a doubling of the current available statistics is expected, thereby improving further the sensitivity to possible BSM effects.

References

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