PROCEEDINGS OF SCIENCE

Higgs Boson measurements in the H→WW→ $\ell\nu\ell\nu$ decay channel

Anamika Aggarwal* on behalf of the ATLAS Collaboration

Radboud University and Nikhef,
Netherlands

E-mail: anamika.aggarwal@cern.ch

Due to its large branching fraction, Higgs boson decays into pairs of W bosons are among the most promising signatures to measure CP and coupling properties of the Higgs boson, as well as its inclusive and differential cross-section. The leptonic final state $\ell\nu\ell\nu$ provides a clean signature and is efficiently selected with lepton triggers. The combination of a high rate and a clean signature provides an opportunity to measure all the major production modes (ggF, VBF, WH, ZH) in a single decay channel. The studies presented here are based on the proton–proton collision data recorded by the ATLAS detector at the LHC at a centre-of-mass energy of 13 TeV with an integrated luminosity up to 139 fb^{-1} data. All the measurements are found to be in agreement with the Standard Model.

40th International Conference on High Energy physics - ICHEP2020
July 28 - August 6, 2020
Prague, Czech Republic (virtual meeting)

PoS(ICHEP2020)093

ATL-PHYS-PROC-2020-106
12 November 2020

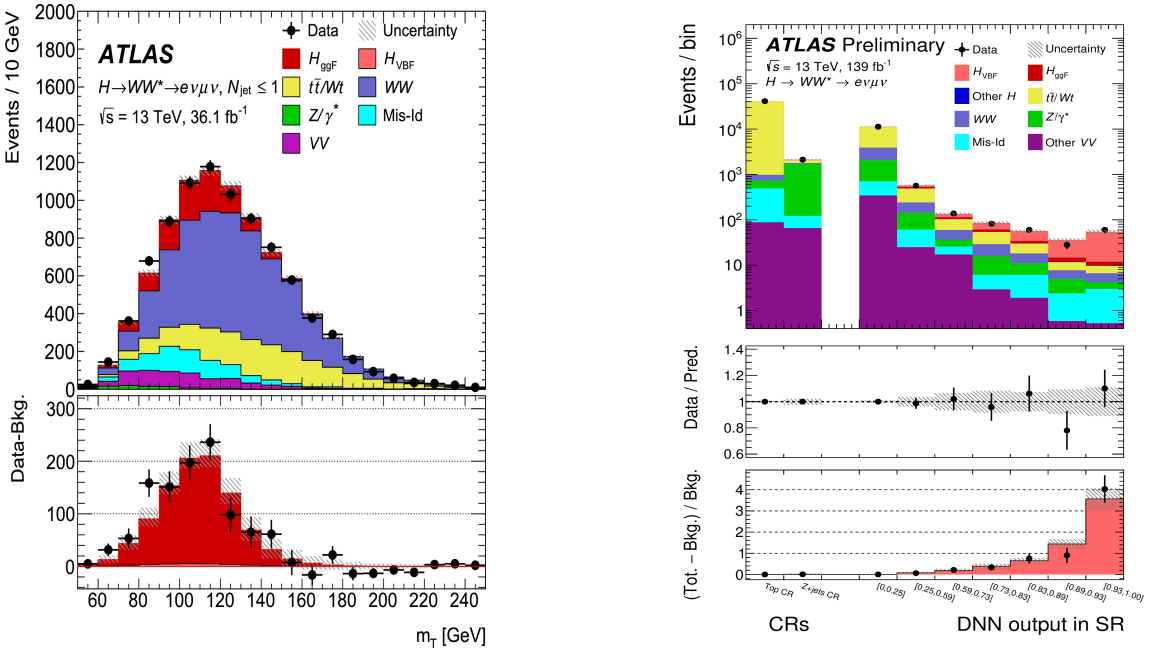
1. Introduction

A review of four different production processes of H→WW→ $\ell\nu\ell\nu$, using data from proton–proton collisions at a centre-of-mass energy of 13 TeV recorded by the ATLAS detector [1], is presented. For the cross-section measurement of gluon fusion and associated WH and ZH production modes, 36.1 fb^{-1} of data are used. For observation in vector-boson-fusion (VBF) production mode, the full LHC Run-2 data samples of 139 fb^{-1} is used.

2. Higgs production through gluon fusion

The gluon fusion Higgs production process probes the coupling of the Higgs boson to gluons via an intermediate heavy quark loop. Events are classified into categories based on the number of jets with $p_{\mathrm{T}} > 30$ GeV [2]. For each jet multiplicity category the signal yield is estimated using the dilepton transverse mass as discrimiinating variable, $m_{\mathrm{T}} = \sqrt{(E_{\mathrm{T}}^{\ell\ell} + E_{\mathrm{T}}^{\mathrm{miss}})^2 - |\vec{p}_{\mathrm{T}}^{\,\ell\ell} + E_{\mathrm{T}}^{\mathrm{miss}}|^2}$ where $E_{\mathrm{T}}^{\ell\ell} = \sqrt{|\vec{p}_{\mathrm{T}}^{\,\ell\ell}|^2 + m_{\ell\ell}^2}$ and $\vec{p}_{\mathrm{T}}^{\,\ell\ell}$ is the vector sum of the lepton transverse momenta.

The observed distribution of the discriminating observable is shown in Figure 1a, and the measured signal strength for gluon fusion Higgs production is measured as $11.4^{+1.2}_{-1.1}(\mathrm{stat.})^{+1.8}_{-1.7}(\mathrm{syst.})$ pb. The observed signal has a significance of 6.0 standard deviations and is in agreement with the SM with the signal strength relative to the SM measured as $\mu_{ggF} = 1.10^{+0.21}_{-0.20}$.



(a) **(b)**

Figure 1: Distribution of the combined transverse mass distribution in the ggF signal region (a) [2], and of the DNN classification score in the VBF region (b) [3]. For the VBF analysis, the event counts in the top-quark and Z+jets control regions are additionally shown.

3. Higgs production through vector boson fusion

The VBF process directly probes the couplings to W and Z bosons at leading order, and can experimentally be distinguished from gluon fusion production through the presence of jets in the forward region. Compared to an earlier result based on 36.1 fb^{-1} [2], a new analysis on 139 fb^{-1} of data has a significantly enhanced sensitivity due to improvements in the object selection criteria, notably including a novel Deep Neural Network (DNN) discriminant [3]. The distribution of the DNN discriminant observable is shown in Figure 1b.

The product of the inclusive VBF cross-section and the H→WW branching ratio is measured to be $0.85^{+0.20}_{-0.17}$ pb, in good agreement with the SM expection: the observed signal strength relative to the SM expectation is $1.04^{+0.24}_{-0.20}$ pb. With an observed (expected) significance of 7.0 (6.2) standard deviations, this measurement constitutes the first observation of the VBF Higgs production in the H→WW decay channel.

4. Higgs production associated with a vector boson

Higgs production in association with a W or Z boson is measured in final states with three or four charged leptons. Events with decays of W/Z bosons to τ leptons are considered as signal, however selection criteria were optimized only for leptonic τ decays [4].

The observed event yields in a selection of signal regions are shown in Figure 2. The product of the WH/ZH cross-sections times the H→WW branching fraction are measured to be $0.67^{+0.31}_{-0.27}(\text{stat.})^{+0.18}_{-0.14}(\text{syst.})$ pb and $0.54^{+0.31}_{-0.24}(\text{stat.})^{+0.15}_{-0.07}(\text{syst.})$ pb, respectively, and are in reasonable agreement with the SM expectation of 0.293±0.007 and 0.189±0.007 pb respectively. The combined signal strength of VH production relative to the SM prediction is measured to be $2.5^{-0.8}_{+0.9}$.

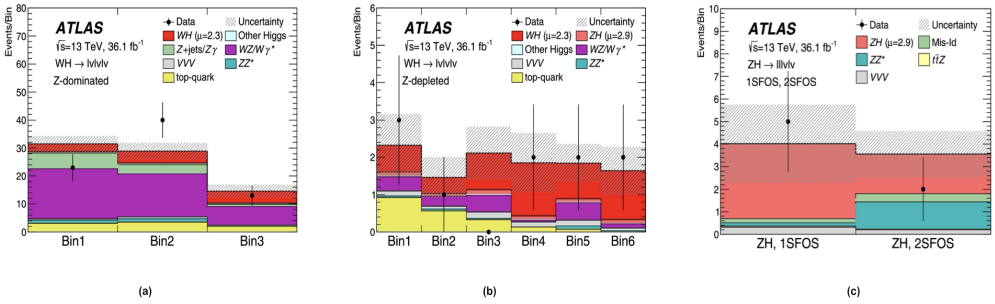


Figure 2: Observed and expected event yields in all signal regions: Z-enriched WH (a), Z-depleted WH (b) and same-flavor opposite-sign ZH (c). Enumerated bins in (a) and (b) correspond to regions with different criteria on the multi-variate classifier. [4]

References

[1] ATLAS Collaboration, 2008 JINST 3 S08003, DOI:10.1088/1748-0221/3/08/S08003
[2] ATLAS Collaboration, Phys. Lett. B 789 (2019) 508, arXiv:1808.09054 [hep-ex]
[3] ATLAS Collaboration, ATLAS-CONF-2020-045, http://cdsweb.cern.ch/record/2728055
[4] ATLAS Collaboration, Phys. Lett. B 798 (2019) 134949, arXiv:1903.10052 [hep-ex]