

## Differential cross section measurements of the Higgs boson in the $H \rightarrow ZZ^* \rightarrow 4l$ and $H \rightarrow \gamma\gamma$ decay channels

G. MANCINI

*INFN-LNF, Frascati, Italy and Università di Roma Tor Vergata, Roma, Italy*

received 7 January 2015

**Summary.** — The measurements of the differential cross sections (XSs) of the Higgs boson in the  $H \rightarrow ZZ^* \rightarrow 4l$  and  $H \rightarrow \gamma\gamma$  decay channels obtained with the ATLAS detector at LHC are presented. Data recorded at  $\sqrt{s} = 8$  TeV (corresponding to  $20.3 \text{ fb}^{-1}$ ) have been used for these analyses. XSs are measured for several observables, involving the Higgs boson kinematics and are selected to be sensitive to its properties. The  $d\sigma/dx$  are determined within the fiducial acceptance of the detector and are corrected for detector efficiencies and resolution effects. Comparisons of the fiducial XSs with several Standard Model-based theoretical calculations are presented and no significant deviation from any of the tested predictions is found.

PACS 14.80.Bn – Standard-model Higgs bosons.

### 1. – Introduction: variables of interest

The differential cross section measurements are performed for several observables related to the Higgs boson production and decay: the  $p_{T,H}$  is sensitive to the Higgs boson production mode and spin/ $CP$  quantum numbers, and can be used to test perturbative QCD predictions;  $|y_H|$  depends on QCD radiative corrections and can be used to probe the proton parton distribution functions (PDF);  $m_{34}$  and  $|\cos(\theta^*)|$  <sup>(1)</sup> are sensitive to the Lagrangian structure of Higgs boson interactions (spin/ $CP$  quantum numbers and higher order operators) and the jet distributions ( $n_{jets}$  and  $p_{T,jet1}$ ) are sensitive to both QCD radiation effects and the relative rates of Higgs boson production modes.

Moreover, the differential distribution  $d\Gamma/dq^2$ , can be used to determine modified Higgs couplings that cannot be directly extracted from a global fit to the signal strengths [1].

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<sup>(1)</sup>  $m_{34}$  is the invariant mass of the off-shell  $Z$  boson and  $|\cos(\theta^*)|$  is the decay angle of the leading lepton pair in the four-lepton rest frame with respect to the beam axis.

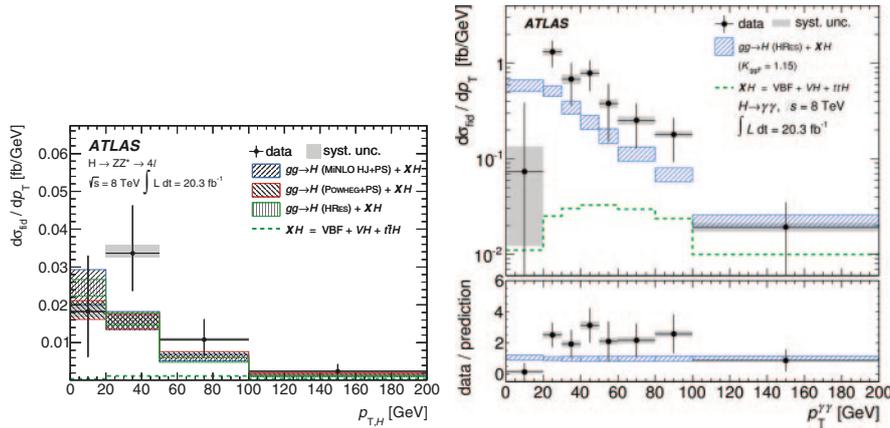


Fig. 1. – Differential XS for the transverse momentum in the  $H \rightarrow ZZ^* \rightarrow 4l$  (left) and  $H \rightarrow \gamma\gamma$  (right) compared to different theoretical calculations of the ggF process. The contributions from VBF, ZH/WH and  $t\bar{t}H$  (denoted as XH), are added to the ggF distributions. The error bars on the data points show the total (stat. $\oplus$ syst.) uncertainty, while the grey bands denote the systematic uncertainties. The bands of the theoretical prediction indicate the total uncertainty.

## 2. – Event selection and Fiducial Region definition

The event selection and the background determination are taken from [2] and [3].

Fiducial XSs are used to minimize the model dependence of the acceptance corrections due to extrapolation to phase space regions not covered by the detector; correction factors in each bin ( $CF_i$ ) are used to unfold the reco distribution to the truth one. The measured fiducial XSs are corrected for detector effects in order to be directly compared to theoretical calculations (HRes2, Powheg-Pythia, Minlo + 1H).

## 3. – Cross section measurements

The signal extraction has been implemented with a simultaneous signal plus background unbinned maximum likelihood fit; therefore, from the measurement of  $n_{i,reco}^{sig}$  the  $(d\sigma/dx)_i$  can be extracted from: 
$$n_{i,reco}^{sig} = \frac{\mu_i \times (d\sigma/dx)_i \times \Delta x_i \times L_{int}}{CF_i}.$$

The best fit values are obtained minimizing the 2NLL (Negative Log Likelihood) and a scan is performed profiling all the other parameters.

The observed inclusive XS in the fiducial region is  $2.11^{+0.53}_{-0.47}(stat)^{+0.08}_{-0.08}(syst)$  (SM-theoretical prediction for  $M_H = 125.4$  GeV is  $1.30 \pm 0.13$  fb) in the  $H \rightarrow ZZ^* \rightarrow 4l$  channel. The  $pp \rightarrow H \rightarrow \gamma\gamma$  fiducial XS is measured to be  $43.2 \pm 9.4(stat)^{+3.2}_{-2.9}(syst) \pm 1.2(lumi)$  fb for a Higgs boson of  $M_H = 125.4$  GeV.

Final results for the observed differential XSs in  $p_{T,H}$  bins, compared to theory predictions, are shown in fig. 1 for both the channels under study.

## 4. – Conclusions

Results presented in both channels, show compatibility, within experimental and theoretical uncertainties, with MC predictions of the SM expectation for the studied variables.

## REFERENCES

- [1] ATLAS COLLABORATION, *Probing the nature of the Higgs-like Boson via  $h \rightarrow V F$  decays*, arXiv:1305.0663v2.
- [2] ATLAS COLLABORATION, *Measurements of fiducial and differential cross sections for Higgs boson production in the diphoton decay channel at  $\sqrt{s} = 8 \text{ TeV}$  with ATLAS* arXiv:1407.4222v2.
- [3] ATLAS COLLABORATION, *Fiducial and differential cross sections of Higgs boson production measured in the four-lepton decay channel in pp collisions at  $\sqrt{s} = 8 \text{ TeV}$  with the ATLAS detector*, arXiv:1408.3226v2.