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Observation of the new Higgs-like particle in the $H \to ZZ^* \to 4l$ searches with the ATLAS detector

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Summary. — An update on the search results of the newly observed Higgs-like boson in the $H \to ZZ^* \to 4l$ decay channel using $20.7\,\text{fb}^{-1}$ at $\sqrt{s} = 8\,\text{TeV}$ and $4.6\,\text{fb}^{-1}$ at $\sqrt{s} = 7\,\text{TeV}$ of data recorded with ATLAS detector at the LHC is given. A clear excess in data has been observed for $m_H = 124.3\,\text{GeV}$; the event selection, the background estimations with data driven methods and the main results are presented.

PACS `14.80.Bn` – Standard-model Higgs bosons.

1. – Introduction

The $H \to ZZ^* \to 4l$ decay channel is referred to as the *Golden Channel* because, despite its low rate ($\sigma \times BR$ (at $m_H = 125\,\text{GeV}$) $\sim 2.5\,\text{fb}$) it has high purity (the ratio Signal/Background being 1.6 at $m_H = 125\,\text{GeV}$) and the signal is characterized by a narrow peak in the 4 leptons invariant mass system.

2. – Event selection

The event selection relies on a cut based analysis in order to select Higgs candidates requiring two pair of same flavoured, opposite charged and high p_T leptons coming from the primary vertex and isolated. Final State Radiation (FSR) photons have been also taken into account, the on-shell Z boson mass has been constrained to the PDG value and the number of mis-pairings leptons to Z has been minimized.

3. – Higgs mass and signal strength

The 4 lepton invariant mass for the selected candidates compared to the background expectation is shown in fig. 1 (upper left). This reflects in a deviation from the background-only hypothesis, that is maximum for $m_H = 124.3\,\text{GeV}$: the local p_0-value observed is 2.7×10^{-11} or $6.6\,\sigma$ (fig. 1 (upper right)). Such results confirm what observed [1] and provides the single channel discovery [2]. The best fit values of the signal strength ($\mu = \sigma_{obs}/\sigma_{SM}$) and m_H are shown in fig. 1 together with the
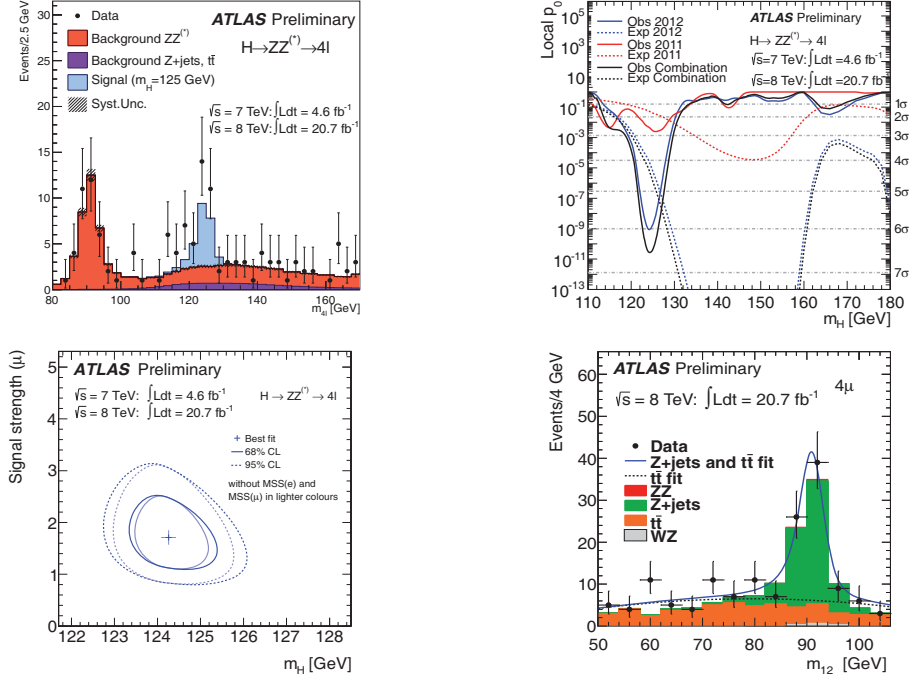
Fig. 1. – Upper left: invariant mass of the 4 lepton system. Upper right: local p_0 as a function of the Higgs mass. Lower left: profile likelihood ratio as a function of μ and m_H. Lower right: invariant mass of the leading leptons from the CR.

profile likelihood ratio contours corresponding to the 68% CL and the 95% CL: μ (at $m_H = 124.3\,\mathrm{GeV}$)$= 1.7^{+0.5}_{-0.4}(stat.)$.

4. – Reducible background (red bkg) from Control Region (CR)

Data driven methods need to be used for the red bkg estimation in the signal region due to the high rejection factor and the theoretical errors on the cross sections; while for the irreducible bkg (ZZ^*), MC samples have been used, since the agreement with data has been verified to be within 10%. CRs (bkg enriched selections obtained inverting isolation and impact parameter requirements) have been defined in order to check the red bkg distribution and to determine its normalization. Figure 1 shows the contribution of the red bkg in the CR, with the $Z + b\bar{b}$ component rescaled with a 1.7 scale factor.

5. – Conclusions

The observation of the Higgs-like particle is fully confirmed in the $H \rightarrow 4l$ decay channel [2]. The integrated luminosity recorded at $\sqrt{s} = 7\,\mathrm{TeV}$ and $\sqrt{s} = 8\,\mathrm{TeV}$ led to the single channel discovery.

REFERENCES

[1] ATLAS COLLABORATION, *Phys. Lett. B*, **716** (2012) 1.
[2] ATLAS COLLABORATION, *Measurements of the properties of the Higgs-like boson in the four lepton decay channel with the ATLAS detector using* $25\,\mathrm{fb}^{-1}$ *of proton-proton collision data*, ATLAS-CONF-2013-013.