Summary of "Observation of a Higgs-like particle in the ATLAS experiment at the LHC"*

The search for the Standard Model Higgs boson has been a major goal of the ATLAS and CMS experiments at the Large Hadron Collider, since the design phase. In several cases, the performance requirements that have driven the project of the sub-detectors were dictated by the optimization of the discovery potential for the Standard Model Higgs Boson in an extremely wide mass range, spanning from 100 GeV up to 1 TeV (see [1] and [2] for the case of ATLAS).

With the rapidly growing statistics of data delivered by the LHC since the 2011 run, several analyses searching for signals of decays of the Higgs Boson have started throughout the collaboration.

In July 2012, the results of the searches, based on 4.8 fb^{-1} collected at $\sqrt{s}$=7 TeV in 2011 and on 5.8 fb^{-1} at $\sqrt{s}$ =8 TeV in 2012, have been published in [3] along with the corresponding results by the CMS Collaboration [4].

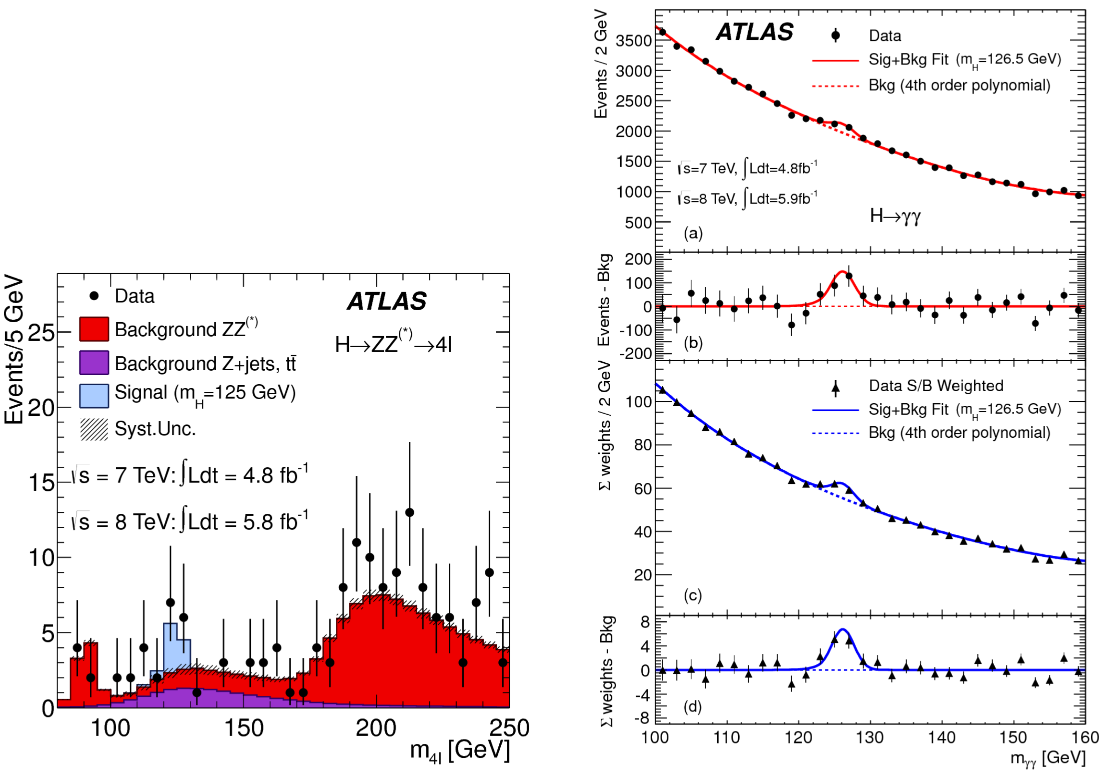

Figure 1. (Left) The distribution of the four-lepton invariant mass, m_{4l}, for the selected event candidates, compared to the background expectation in the 80 to 250 GeV mass range. Data from $\sqrt{s}$ = 7 Tev and 8 TeV are combined in the plot. The signal expectation for a SM Higgs with m_H = 125 GeV is superimposed to background from other physics processes. (Right) Distributions of the invariant mass of di-photon candidates after all selections for the combined 7 TeV and 8 TeV data sample. The inclusive sample is shown in a) and a weighted version of the same sample in c); the weights are explained in [3]. The result of a fit to the data of the sum of a signal component fixed to m_H = 126.5 GeV and a background component described by a fourth-order Bernstein polynomial is superimposed. The residuals of the data and weighted data with respect to the respective fitted background component are displayed in b) and d)

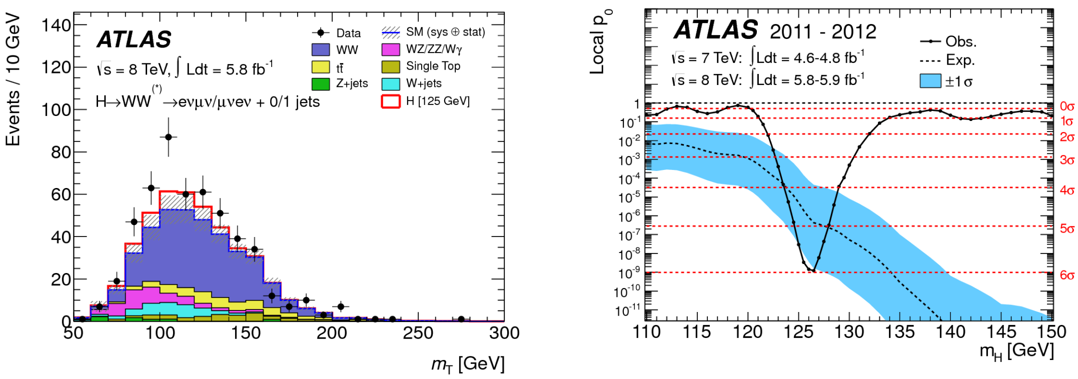

Figure 2. (Left) Distribution of the transverse mass, m_T, for events satisfying the selection criteria for $WW \to e\nu\mu\nu$. The expected signal for $m_H = 125$ GeV is shown stacked on top of the background prediction. The W+jets background is estimated from data, and WW and top background MC predictions are normalised to the data using control regions. The hashed area indicates the total uncertainty on the background prediction. (Right) The observed (solid) local p_0 as a function of m_H in the low mass range. The dashed curve shows the expected local p_0 under the hypothesis of a SM Higgs boson signal at that mass with its plus/minus one sigma band. The horizontal dashed lines indicate the p-values corresponding to significances of 1 to 6 sigma

The decay channels investigated in the paper [3] are $H \to ZZ^* \to 4l$[1], $H \to \gamma\gamma$, $H \to WW^* \to e\nu\mu\nu$, $H \to b\bar{b}$ and $H \to \tau\bar{\tau}$. For a Higgs of low mass, in spite of the larger production cross section times branching fractions of the channels with two fermion final states, the search for these decays is experimentally difficult, due to the large background, especially in the most aboundant Higgs production mode, which proceeds through gluon-gluon fusion, via a virtual loop involving a heavy particle like the top quark. The $ZZ^* \to 4l$ channel has good sensitivity due to the very clean final state, the wide acceptance of the ATLAS detector for triggering and reconstructing electrons and muons and the excellent momentum resolution. The low background arises from the irreducible continuum $Z/\gamma - Z/\gamma$ production, the production of Z+jets, where fake prompt leptons are reconstructed in the event, and the pair production of top quarks, where leptons come from semileptonic decays of b- and c-quarks or from the misidentification of jets. The event selection, optimized on a blind analysis based on simulation and extrapolation of SM backgrounds from control regions up to the low m_H signal region, results in the $4l$ invariant mass distribution shown in the left plot of figure 1. Here an excess of events clustering around the mass value of 125 GeV can be observed and compared with the expectation from a signal coming from a SM Higgs boson of mass $m_H = 125$ GeV.

In summmary, the observed local p_0, representing the probability of a background fluctuation up, or above, the observed number of events, from the combination of all channels is reported in the right plot of figure 2 as a function of the m_H. The smallest value of p_0 is observed for $m_H = 126.5$ GeV and it corresponds to a deviation with respect to the background expectation of six standard deviations. Finally, in figure 3 the signal strength (ratio of the observed rate of events in the data to the expectation for a SM Higgs boson) is shown for all individual decay channels (left plot) and it is displayed as a function of m_H for the three most sensitive channels with di-boson final states.

The result described in [3], briefly summarized here, is a major achievement of experimental particle physics at accelerators. This short contribution has been prepared in the name of the members of the Lecce ATLAS team whose composition evolved with time from the start of the ATLAS activities in Lecce up to today. They are: M. Bianco[2,3], I. Borjanovic[4,3], G. Cataldi[5], G. Chiodini[5], E. Gorini[5,6], F. Grancagnolo[5], S. Grancagnolo[7,3], N. Orlando[5,6], R. Perrino[5], M. Primavera[5], G. Sira-

[1] The symbol l is used to refer generically to an electron or a muon.
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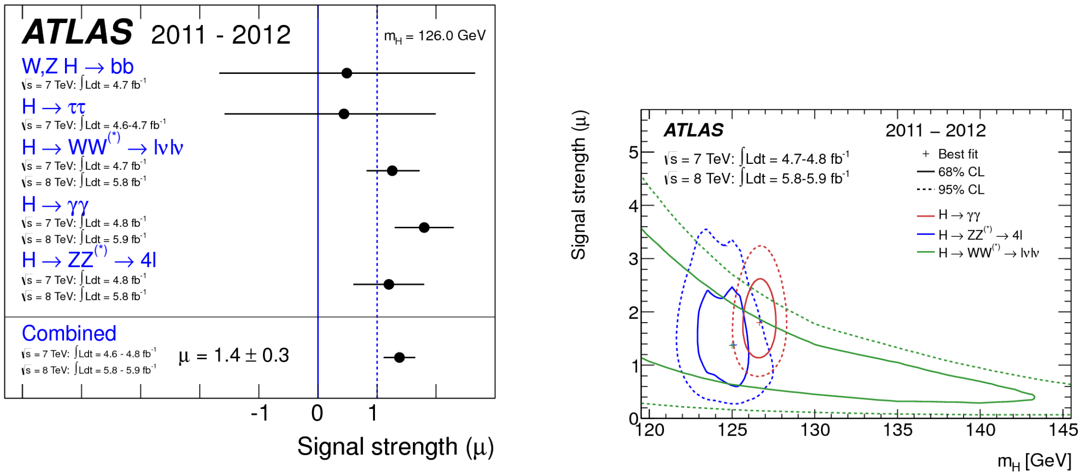

Figure 3. (Left) Measurements of the signal strength parameter μ for $m_H = 126$ GeV for the individual channels and their combination. (Right) Confidence intervals in the (μ, m_H) plane for the $H \rightarrow ZZ^* \rightarrow 4l$, $H \rightarrow \gamma\gamma$, and $H \rightarrow WW^* \rightarrow l\nu l\nu$ channels, including all systematic uncertainties. The markers indicate the maximum likelihood estimates ($\hat{\mu}$, $\hat{m}_H$) in the corresponding channels (the maximum likelihood estimates for $H \rightarrow ZZ^* \rightarrow 4l$ and $H \rightarrow WW^* \rightarrow l\nu l\nu$ coincide).

gusa[83], S. Spagnolo[56] and A. Ventura[56], who had the chance to sign, along with the rest of the ATLAS Collaboration, the paper [3], some of them currently active in the experiment, others strongly involved until recently; E. Fasanelli[5], G. Fiore[5], A. Innocente[5], A. Miccoli[5] and F. Ricciardi[5], whose technical support is today, as in the past, unvaluable for the success of the ATLAS physics program; E. Brambilla[3], A. Cazzato[3], M.R. Coluccia[56], P. Creti[5], R. Crupi[3], R. Gerardi[56], S. Golovatyuk[93], A. Guida[3], A. Leone[5], C. Pinto[56] and S. Podladkin[3], who as technicians, engineers, PhD students, post-Docs, associate scientists have contributed in the past years to the overall impact of Lecce in ATLAS; finally, L. Longo[56] and M. Reale[56], currently Master Thesis students, who are mentioned to remind of the contributions of all the past students and of the next generations which will consolidate and renew the venture. They are pleased to have been part of this success by contributing to several activities over the past two decades: the Resistive Plate Chamber (RPC) design, assembly, testing, certification, installation, commissioning and maintenance; the muon Event Filter deployment and the muon High Level Trigger commissioning, monitoring and validation; the muon offline reconstruction and simulation software development; the RPC and Level-1 trigger studies with data; the studies with data of the performance for triggering and reconstructing muons for the ATLAS physics analyses. They acknowledge the support through the years of the entire personnel of Sezione INFN of Lecce and of Dipartimento di Matematica e Fisica "Ennio De Giorgi" and share with them the pride and excitement of this historical moment.

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