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Higgs results in the $WW^{(*)} \to l\nu l\nu$ decay channel at ATLAS

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Summary. — The evidence for the SM Higgs-like boson in the $H \to WW^{(*)} \to l\nu l\nu$ channel using the complete data samples collected in 2011 and 2012 by the ATLAS experiment at the LHC, at a centre of mass energy of 7 TeV and 8 TeV, respectively, is presented. The total integrated luminosity is about 25 fb^{-1}. The analysis focuses on a SM Higgs boson with a mass of 125.5 GeV produced through gluon-gluon fusion (ggF) and vector-boson fusion (VBF). An excess over the expected number of background events is observed with a significance of 3.8 standard deviations, and the expected value is 3.8. The signal strenght is consistent with the Standard Model expectation. The combined result with $WH \to WWW^{(*)} \to l\nu l\nu l\nu$ and $ZH \to ZWW^{(*)} \to lll\nu l\nu$ is also reported.

PACS 14.70.Fm – W bosons.
PACS 14.80.Bn – Standard-model Higgs bosons.

1. – Analysis strategy and backgrounds

The $H \to WW^{(*)} \to l\nu l\nu$ ($l = \mu, e$) decay mode provides direct access to the Higgs boson couplings to W bosons. It has a large rate, but the presence of neutrinos in the final state limits the reconstruction of a narrow mass peak. The signature consists in two leptons with opposite charge and the presence of missing transverse momentum. Events are classified in bins of jet multiplicity (Njet) to better control the background; in the Njets $\leq$ 1 bin the signal comes almost entirely from the ggF process and the dominant background is due to the $WW^{(*)}$ production, while the sensitivity to the VBF production mode is driven by the Njets $\geq$ 2 bin, which is dominated by the top quark background. Spin correlations in the decay of a SM Higgs boson and the $V-A$ structure of the W decay imply that the charged leptons are produced in the same direction; requirements on the invariant mass and the azimuthal gap of the leptons are therefore exploited to reduce the WW non-resonant background. In the Njets $\geq$ 1 analyses, the top quark background is reduced by rejecting events with a b-tagged jet. There is also a large amount of Drell-Yan (DY) events ($pp \to Z/\gamma^* \to ll$) that enter the selection either because of the leptonic decays of τ leptons or because they are reconstructed with fake

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missing transverse momentum, especially in the 8 TeV run where the pile up is high. To reduce the DY background additional requirements are made on the variable frecoil, a measurement of the soft hadronic recoil opposite to the system of the leptons and any accompanying jet; frecoil is higher in DY events than non-DY events, where the system is in part balanced by the recoiling neutrinos. $W+$jets events have a fake lepton in the final state, and are reduced by using a tight lepton identification and isolation criteria. The Njets $\geq$ 2 channel is optimized for VBF. For selecting events produced in the VBF mode the two highest-p_T jets are required to have a large rapidity separation and a high invariant mass, and the activity in the rapidity gap is required to be small in order to limit the contamination from ggF. The backgrounds from WW, top quark and $Z \to \tau\tau$ are normalized using control regions, while W+jets and Z/γ^* events are difficult to model and are therefore estimated from data; diboson processes in the Njets $\geq$ 2 analysis are estimated using the MC simulation.

2. – Results

The leading theoretical systematic uncertainties on the signal yield are the QCD renormalisation and factorisation scales, that affect the signal yield in the different jet bins, while the leading experimental ones are the jet energy scale and resolution. The distribution of the transverse mass m_T, defined as $m_T = ((E_T^{ll}+E_T^{miss})^2 - |\mathbf{p}_T^{ll}+\mathbf{E}_T^{miss}|^2)^{1/2}$ with $E_T^{ll} = (|\mathbf{p}_T^{ll}|^2 + m^2)^{1/2}$, is used to fit the data and extract the signal strength. The signal region is split into two bins of the invariant mass of the two leptons system, m^{ll}, in order to improve the significance. An excess of events is observed in data with respect to the background only expectation. The significance of the excess for $m_H = 125.5\,\text{GeV}$ is 3.8 standard deviations, and the expected value is 3.8. The measured signal strength is $\mu = 0.99 + 0.31$–0.28, consistent with the Standard Model expectation [1].

3. – Combination with VH

In the $WH \to WWW^{(*)} \to l\nu l\nu l\nu$ and $ZH \to ZWW^{(*)} \to lll\nu l\nu$ processes the Higgs boson is produced in association with a vector boson, and the final state consists of three and four leptons, respectively, and missing transverse momentum carried away by the neutrinos. No significant excess over the Standard Model expectation is observed in this production mode. The observed (expected) limits at 95% confidence level on the cross section ratio to the Standard Model prediction are 7.2 (3.6) times the Standard Model cross section for a Higgs boson of mass $m_H = 125\,\text{GeV}$. The data are compatible with the background-only hypothesis at the 2.0 σ level [2]. The VH results have been combined with the results of the $H \to WW^{(*)} \to l\nu l\nu$ analysis. The combined expected and observed significances, for $m_H = 125\,\text{GeV}$, are 3.8 and 4.0 standard deviations [2,3].

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