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Study of $H \to WW^{(*)}$ events with the ATLAS detector

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Summary. — The Higgs boson decay into WW$^{(*)}$ is an interesting channel in a wide Higgs mass (m_H) range. In particular the high Branching Ratio (BR) allows $H \to WW^{(*)}$ to be one of the most important channels for all the studies related to the Higgs boson properties. The fully leptonic final state of this channel provides a clear signature and allowed the observation of a Higgs boson with $m_H \sim 125\,\text{GeV}$ in the data collected by ATLAS until 2012.

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1. – Analysis

The study of $H \to WW^{(*)}$ events in the ATLAS detector is used to investigate several processes, in particular the different Higgs boson production mechanisms at LHC. The present work is focused on the direct production and mainly on the gluon gluon fusion (ggf) and on the vector boson fusion (vbf) and is based on the study performed using $20.7\,\text{fb}^{-1}$ of proton-proton collision data at a centre-of-mass energy of 8 TeV collected in 2012 with the ATLAS detector [1]. The associated producion of an Higgs boson with a vector boson was searched for in proton-proton collisions at 7 TeV [2]. The topology of the $H \to WW^{(*)}$ events is simple, the signature is provided by missing transverse energy (MET) and two leptons of opposite charge and high trasverse momentum (p_T). Focusing on the direct production, the main backgrounds are the standard model WW (defined as irriducible background), the WZ, the ZZ and the V+jets (mainly W+jets) productions. All the selections are described in ref. [1], the events are classified by lepton flavor combinations, same flavor (SF) and different flavor (DF), and by jet multiplicity. The first distinction is made because of the different background composition in SF and DF events. The Drell-Yan and Z+jets production are dominant in the SF category. The events are divided accordingly to the jet multiplicity for two reasons: different background composition and different Higgs boson production processes. The main production process in the 0 or 1 jet cases is ggf, while for a jet multiplicity larger than 2 it is the vbf. Focusing on the 0 jet DF flavor channel the selections are mainly connected to the leptons p_T, the MET

TABLE I. – *Observed and expected events in the 0 jet DF channel.*

Selection	N_{obs}	N_{bkg}	N_{sig}
$N_{jet} = 0$	9024	9000 ± 40	172 ± 2
$p_T^{ll} > 30$	5497	5490 ± 30	156 ± 2
$\|\Delta\phi_{ll}\| < 1.8$	1399	1240 ± 10	119 ± 1

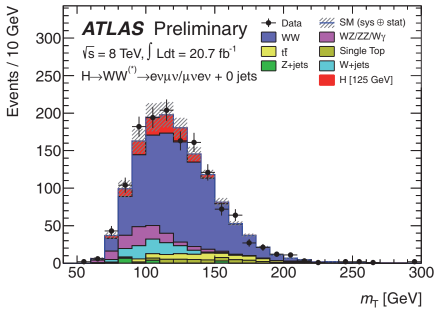

Fig. 1. – m_T distribution for the 0 jet DF channel [1].

and the trasverse momentum of the dilepton pair (p_T^{ll}). To suppress the irriducible background a selection on the opening angle between the two leptons ($\Delta\phi_{ll}$) is considered. The $\Delta\phi_{ll}$ distribution for the WW standard model production is flat while for the WW pair coming from the Higgs boson decay the distribution peaks at low values. In table I the number of signal, background and observed events at different cutflow stages is presented.

Because of the MET presence it is impossible to recostruct the exact invariant mass of the Higgs boson candidate. To test the presence of signal the trasverse mass (m_T) is introduced, $m_T = \sqrt{(E_T^{ll} + E_T^{miss})^2 - |\vec{p}_T^{\,ll} + \vec{p}_T^{\,miss}|^2}$. The distribution in the 0 jet DF channel for this variable is presented in fig. 1.

2. – Results

The $H \to WW^{(*)}$ channel contributes togheter with other ggf and vbf production channels to the observation and measurement of the properties of the new boson with $m_H \sim 125\,\text{GeV}$. From the analysis of this channel alone the probability of obtaining the observed number of events from a background fluctuation in the absence of any signal (p_0) is 3.8σ. The measured signal streght is $\mu = 1.01 \pm 0.31$. The measured cross section is $6.0 \pm 1.6\,\text{pb}$ compatible with the standard model expectation ($4.8 \pm 0.7\,\text{pb}$). The analysis of the angular distributions with $H \to WW^{(*)}$ events supports the spin 0 hypothesis [3].

REFERENCES

[1] ATLAS COLLABORATION, ATLAS-CONF-2013-030.
[2] ATLAS COLLABORATION, ATLAS-CONF-2012-078.
[3] ATLAS COLLABORATION, ATLAS-CONF-2013-031.