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Search for the standard model Higgs boson decaying into tau pairs produced in association with a W or Z boson

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Summary. — A search of the Standard Model (SM) Higgs boson production in association with a vector boson, W or Z, is performed at LHC, using data collected with the CMS detector during 2011 and 2012, corresponding to a total integrated luminosity of 24.5 fb^{-1}. The associated production represents an interesting channel for the low-mass Higgs boson search, thanks to the presence of highly energetic leptons coming from W and Z decays which suppress the most relevant SM backgrounds. The Higgs decay search is performed in the di-τ decay mode, in which each τ can decay into an electron, a muon or hadronically (τ_h) and a neutrino. The WH channel has three leptons in the final state, with W decaying into electron or muon and a neutrino; instead the ZH channel is performed in a four leptons final state, where the Z decays into a pair of electrons or muons. The data analysed are compatible with the SM expected background, and no significant excess is observed.

PACS 14.80.Bn – Standard-model Higgs bosons.
PACS 07.05.Hd – Data acquisition: hardware and software.
PACS 29.85.Fj – Data analysis.

1. – Event selection

The final states studied in WH channel are $\mu\mu\tau_h$, $e\mu\tau_h$, $\mu\tau_h\tau_h$ and $e\tau_h\tau_h$, instead in the ZH channel are $(\mu\mu, ee) \times (\mu\tau_h, e\tau_h, e\mu, \tau_h\tau_h)$, selected by dedicated leptonic triggers [1]. All channels use a strategy identical to the inclusive CMS H $\rightarrow \tau\tau$ search for identifying e, μ, τ_h and jet candidates [2]. The cut-based analysis requires isolated leptons and topological cuts, like no b-jets and no extra leptons, in order to identify the candidates W (or Z) and Higgs.

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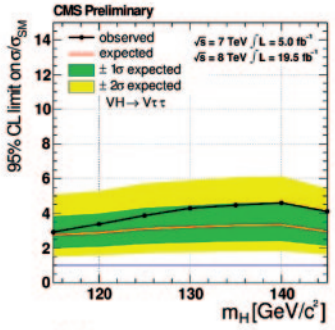
Process	$\ell\ell\tau_h$	$\ell\tau_h\tau_h$	$\ell\ell LL$
Reducible backgrounds	26.3 ± 4.7	20.8 ± 4.2	25.2 ± 10.0
WZ	35.3 ± 3.9	6.3 ± 0.9	
ZZ	2.5 ± 0.3	0.39 ± 0.08	27.2 ± 3.8
Total bkg.	64.1 ± 6.2	27.5 ± 4.3	52 ± 11
VH→Vττ ($m_H = 125\,\mathrm{GeV}/c^2$)	3.6 ± 0.4	1.2 ± 0.2	2.1 ± 0.2
VH→VWW ($m_H = 125\,\mathrm{GeV}/c^2$)	0.50 ± 0.05	0	1.13 ± 0.09
Observed	65	36	66

(a)



(b)

Fig. 1. – (a) Observed events and expected yields from different background. (b) Observed and expected range of 95% CL upper limits on SM Higgs boson production.

2. – Background estimation

The irreducible backgrounds come from the decay of W (or Z) in real leptons and are estimated from simulation. The reducible backgrounds are characterized by the presence of at least one quark or gluon jet which is misidentified as lepton (*fake lepton*) and are estimated from data, using the *fake rate technique*. A background-enriched region is selected to measure the probability of a jet to pass identification and isolation criteria in terms of p_T (*fake rate*), which is used to evaluate the expected background in the signal region, weighting events in which the final object requirements are inverted.

3. – Results and systematic uncertainties

After all selections the observed data are compatible with expected background (fig. 1a). As data show no evidence for the presence of a Higgs boson, 95% CL upper limits are set on the SM Higgs boson production cross section (fig. 1b).

4. – Conclusion

A search for the associated production of the SM Higgs boson decaying into tau pairs is performed. The final states in three or four isolated leptons are searched using the $24.5\,\mathrm{fb}^{-1}$ data recorded by CMS [3]. The yields are compatible with both the background-only hypothesis and the presence of a SM Higgs Boson. Upper bounds at 95% CL between 2.9 and 4.9 times the SM prediction are set for the product of the SM Higgs boson production cross section and decay branching ratio in the mass range $110 < m_H < 145\,\mathrm{GeV}/c^2$.

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