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Search for the standard model Higgs boson in associated WH production in the $e\mu\tau$ and $\mu\mu\tau$ final states

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Summary. — A search for WH events has been performed by using data collected in 2011 at CMS corresponding to $4.7\,\mathrm{fb}^{-1}$. No signal is found and therefore upper limits are given in the Higgs mass range $[100, 140]\,\mathrm{GeV}/c^2$.

PACS 07.05.Hd – Data acquisition: hardware and software.
PACS 07.05.Kf – Data analysis: algorithms and implementation; data management.
PACS 07.05.Rm – Data presentation and visualization: algorithms and implementation.
PACS 29.85.fJ – Data analysis.

1. – Introduction

At the LHC, the Standard Model (SM) Higgs boson is expected to be produced mainly from gluon and vector boson fusion. A secondary process is the Higgs production in association with vector bosons which, despite the lower cross section, provides an additional sensitive channel thanks to the higher background rejection achieved through the additional highly energetic leptons from the W/Z decays. Moreover, in the light-mass region, Higgs decay into τ-lepton pairs has the second highest braching ratio, after the decay in $b\bar{b}$ (more difficult to reconstruct). For these reasons, a search for the WH production, where the Higgs decays into tau pairs, has been performed based on data collected with the CMS detector [1] during 2011 and corresponding to an integrated luminosity of $4.7\,\mathrm{fb}^{-1}$. A full data-driven background estimation is also presented.

2. – Event selection

Candidate WH events are selected with trigger paths, which require either two muons or one high-p_T muon and one electron. All final leptons are required to be associated to the reconstructed primary vertex with highest p_T sum. At offline level the following requirements are applied: minimum transverse momentum and pseudorapidity, identification and isolation [2, 3]. The hadronic tau decay (τ_{had}) identification is performed

a)

Source	Value
Luminosity	4.5%
σ_{WZ}	16.6%
σ_{ZZ}	40%
σ_{H} (PDF)	4.5%
σ_{rare}	100%
MC Eff. L_T	5%
MC Stat.	5–30%
Fakes	30% + CR stat.
Tau energy scale	1–2.5%
Tau ID	6%
Muon ID + Iso	1%
Electron ID + Iso	2%

b)

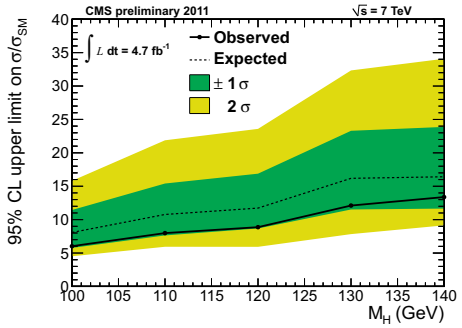

Fig. 1. – a) Systematic uncertainties applied in WH analysis. b) Observed and expected range of 95% CL upper limits on SM Higgs boson production.

using an algorithm in which one or three charged hadrons are combined with photons to reconstruct τ decay modes individually [4]. A cut on the scalar sum of the transverse energy of the WH candidate components is applied to remove fake backgrounds with softer p_T spectrum. In order to remove the fake jet $\rightarrow \tau_{had}$ background contribution the absolute sum of the charges of the three final-state objects is required to be one [2].

3. – Background estimation and efficiency corrections

The irreducible backgrounds (WZ, ZZ, $t\bar{t}W$, WWW) are estimated from the simulation. The reducible backgrounds ($Z/W/t\bar{t}+$ jets, QCD) in which a jet fakes one or more isolated leptons, are estimated through a fake-rate technique [2]: the probability for a jet to fake an isolated lepton is measured in suitable control regions in terms of jet p_T and it is used to weight events in background enriched regions, obtained by inverting the lepton isolation requirements. The final-state charge assignment assures that only light leptons can be faked by a jet [2]. Monte Carlo samples have been reweighted to take into account the additional interactions observed in the data due to multiple p-p interactions per bunch crossing. The efficiencies for electron and muon reconstruction, identification, and isolation, as well as the cross-trigger efficiencies are measured in data by using a tag-and-probe technique. The simulated samples are scaled by correction factors corresponding to the differences between the measured and simulated efficiencies. Corrections to the jet energy scale are applied in data and Monte Carlo samples.

4. – Conclusions

A search for WH events has been performed using $4.7\,\mathrm{fb}^{-1}$ of 2011 CMS data. Two WH final states were used ($\mu\mu\tau$, $e\mu\tau$) and a total of nine events are selected that are compatible with the expectation from the (non-Higgs) Standard Model background. As

no excess is observed, an upper limit of 6–13 times greater than the predicted value is set at 95% CL for the product of the SM Higgs boson production cross section and decay branching fraction in the mass range $100 < M_H < 140\,\text{GeV}$ (fig. 1).

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