PROCEEDINGS OF SCIENCE

Search for the Standard Model Scalar boson decaying to tau pairs and produced in association with a Z boson

Lucia Perrini* **on behalf of the CMS Collaboration**
Université Catholique de Louvain-la-Neuve, Belgium
E-mail: lucia.perrini@uclouvain.be

A search for the Standard Model Higgs boson decaying to tau pairs is presented using data collected in 2011 and 2012 with the CMS experiment at the LHC. The search is performed in the four-lepton final state topology, where the Higgs boson is produced in association with a Z boson decaying to a pair of electrons or muons. The analyses uses pp collision data corresponding to integrated luminosities of 5 fb^{-1} collected at $\sqrt{s}$ =7 TeV and 19.5 fb^{-1} collected at $\sqrt{s}$ =8 TeV.

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*Speaker.

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1. Introduction

The mechanism of spontaneous electroweak symmetry breaking is introduced in the Standard Model (SM) to give mass to the vector bosons, while keeping the photon massless. This mechanism results in a scalar called the Higgs boson (H). The analysis summarized in this document is focused on the search for the SM Higgs boson produced in association with a Z and decaying to two taus. The presence of isolated high momentum leptons from Z suppresses the backgrounds dramatically.

2. Event selection

Eight final states have been considered in the ZH search: $lle\mu$, $lle\tau_h$, $ll\mu\tau_h$ and $ll\tau_h\tau_h$, where ll are either ee or $\mu\mu$ from the Z and τ_h from H refers to a τ decaying hadronically. A double muon and a double electron trigger have been used for the online event selection. The leading and sub-leading leptons associated to the Z are required to have opposite charge and transverse momentum (p_T) greater than 20 and 10 GeV, respectively. To reject the $t\bar{t}$ background, the leptons associated to the Z are required to have an invariant mass in the range 60$< M_Z <$ 120 GeV and any event containing a b-jet is rejected. The leptons associated to the Higgs boson candidate must have opposite charge, p_T >10 GeV in the case of electrons or muons and p_T >20 GeV in the case of taus decaying hadronically.

3. Background estimate and the fake-rate technique

The ZZ irreducible background is estimated from Monte Carlo simulation. The dominant reducible backgrounds, represented by Z+jets and WZ+jets, are estimated with a data-driven technique called *fake-rate method*.
The *fake-rate* is defined as the probability that a genuine jet that passes some loose lepton identification and isolation requirements also passes the final, tight requirements. It is measured as a function of the p_T of each fake candidate (e, μ or τ_h) in background enriched regions. These regions are defined by requiring the same trigger and quality criteria as in the final selection, but the leptons coming from the Higgs candidate are required to have the same charge. The number of those leptons passing loose identification and isolation requirements, but failing the tight ones, is measured.

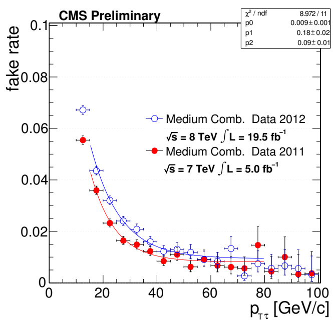

Figure 1. τ fake rate as a function of τ p_T.

The method consists of weighting each event with a loose lepton not passing the tight criteria by the probability $p = f/(1-f)$ where f is the fake-rate function. The τ_h fake rate, fitted with an exponential function, is shown in figure 1.

4. Systematic uncertainties

The uncertainty on the total integrated luminosity is 2.2%(4.4%) for 7(8) TeV data. The theoretical uncertainty accounted for the ZZ cross-section is 10% and it is due to the parton distribution

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Process	$\ell\ell$LL
Reducible backgrounds	25.2±10.0
ZZ	27.2±3.8
Total bkg.	**52±11**
ZH→Z$\tau\tau$ (m_H=125 GeV/c^2)	**2.1±0.02**
ZH→ZWW (m_H=125 GeV/c^2)	**1.13±0.09**
Observed	**66**

Table 1. Observed events and expected yields. The uncertainties are statistical and systematic combined.

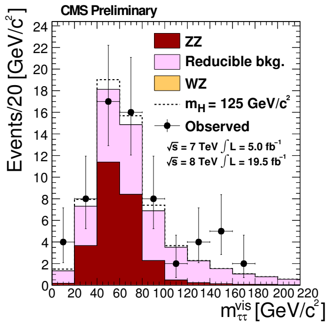

Figure 2. The expected spectra of the Higgs boson candidate visible mass for the 7+8 TeV data.

functions (PDF) and to the QCD renormalization scale. The theoretical uncertainty on the signal cross section is instead 4%. The uncertainties on the simulation-to-data correction factors include trigger (1%), and identification and isolation efficiencies for muons and electrons (varying in the range 2-6%). The τ_h identification efficiency, measured with an uncertainty of 6%, leads to a 12% uncertainty when two τ_h are in the final state.

5. Results and limits

The number of events in data and expected yields from all backgrounds are in the table 1. The observed data are compatible with the background expectation within the errors. The observable used in this analysis are the distributions of the visible invariant mass of the tau pair associated to the Higgs boson candidate. The reconstructed 2τ visible mass for all decay channels is presented in the figure 2.

The observed and expected 95% limits have been performed by using the asymptotic CLs method [4]. Upper limit of 6.2 times the predicted SM value is set on the product of the SM Higgs boson production cross section and decay branching fraction for the mass 125 GeV/c^2 (all the limit values set in the range 110< m_H <145 GeV/c^2 are shown in the figure 3).

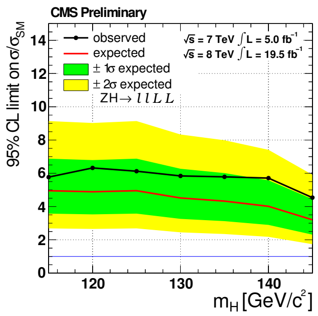

Figure 3. Limits on SM Higgs boson production.

References

[1] The CMS Collaboration, *Observation of a new boson at a mass of 125 GeV with the CMS experiment at the LHC*, *Phys. Lett.* B **716** (2012) 30-61.

[2] The ATLAS Collaboration, *Observation of a new particle in the search for the Standard Model Higgs boson with the ATLAS detector at the LHC*, *Phys. Lett.* B **716** (2012) 1-29.

[3] The CMS Collaboration, *Search for a Standard Model Higgs boson decaying to tau pairs produced in association with a W or Z boson*, **CMS-PAS-HIG-12-053**.

[4] G. Cowan, K. Cranmer, E. Gross, O. Vitells, *Asymptotic formulae for likelihood-based tests of new physics*, **European Physical Journal C**.