PROCEEDINGS OF SCIENCE

A search for the Higgs boson in the channel H $\to \gamma\gamma$ with the CMS detector

Daniele DEL RE* **on behalf of the CMS collaboration**
Sapienza University of Rome and INFN Rome
E-mail: delre@roma1.infn.it

We report on the search for a Higgs boson decaying into diphotons in pp collisions at the LHC at a center-of-mass energy of 7 TeV with CMS. The dataset corresponds to 1.66 fb^{-1} of data recorded in the first half of 2011. The expected exclusion limit at 95% CL is between 2.7 and 4.7 times the Standard Model cross section, and the observed limit fluctuates between about 1.3 and 8 times the Standard Model cross section. For the fermiophobic model, the expected exclusion limit at 95% CL covers the mass range between 110-116.5 GeV, while the data excludes the mass range 110-112 GeV.

The 2011 Europhysics Conference on High Energy Physics-HEP 2011,
July 21-27, 2011
Grenoble, Rhône-Alpes France

*Speaker.

PoS(EPS-HEP2011)247

1. Introduction

The Standard Model of particle physics (SM) provides a very successful description of the presently known phenomena. An open question is about the electroweak symmetry breaking mechanism which can be explained via the Higgs mechanism. The additional scalar field, the Higgs boson, should be experimentally observable. The combination of direct searches and indirect constraints from precision electroweak data indicates that the mass of the SM Higgs should be lower than 143 GeV (95% CL) [1]. In this region, H$\to\gamma\gamma$ is one of the most promising channels for Higgs discovery. Previous searches in this channel have been conducted by the CDF and D0 experiments [2, 3].

Here we report on a search for a Higgs boson decaying into two photons in pp collisions at a center-of-mass energy of 7 TeV with CMS [4]. The dataset consists of diphoton triggered events corresponding to an integrated luminosity of 1.66 fb^{-1}. A further search has also been made in the fermiophobic scenario, where the Higgs only couples to bosons.

2. Reconstruction, selection, and event classes

Photon candidates are reconstructed from clusters of the electromagnetic calorimeter of CMS (ECAL) channels [5] around significant energy deposits. The clustering algorithms is designed to recover the energy of photons that convert in the material in front of the ECAL. The resulting set of crystals assigned to a photon is called supercluster. The identification of converted photons is performed using the topological variable R9, which is the energy sum of 3$\times$3 crystals centered on the most energetic crystal in the supercluster divided by the energy of the supercluster. If R9 > 0.94, the photon is likely unconverted.

The events used in this analysis are selected at trigger level requiring a loose calorimetric identification based on shower shape and very loose isolation requirements on both photon candidates. The thresholds in transverse momentum (p_T) are at least 10% lower than the final selection thresholds which corresponds to $p_T > 40(30)$ GeV for the highest (lowest) p_T photon. The offline selection requires the photon candidates within the ECAL fiducial region ($|\eta| < 2.5$) and excluding the barrel-endcap transition region $1.4442 < |\eta| < 1.566$. To reject the reducible background represented by QCD and photon+jet events, where one or two jets are misidentified as a photon, isolation requirements are applied. They are based on the sum of the p_T of the tracks and the calometric objects which lie within a cone around the photon, subtracted of the pile-up energy density. Additional requirements are applied to reject the contamination of leptons, conversions, and neutral pions which are based on an explicit electron veto and on the cluster shape of the photons. To maximize sensitivity, reconstructed photons are divided into 4 categories based on R9 (R9>0.94 and R9<0.94) and on whether the photon is in barrel or endcap. A different tightness of selection is applied in each category. The efficiency of this selection is measured in data using tag and probe techniques. $Z \to ee$ events are used to determine the efficiency of the selection except for the electron veto cut. $Z \to \mu\mu\gamma$ events are used to measure the efficiency for photons to pass the electron veto. Even if the Monte Carlo (MC) simulation of the background processes is not used in the analysis, the diphoton mass spectrum is found to agree with the distribution predicted by MC

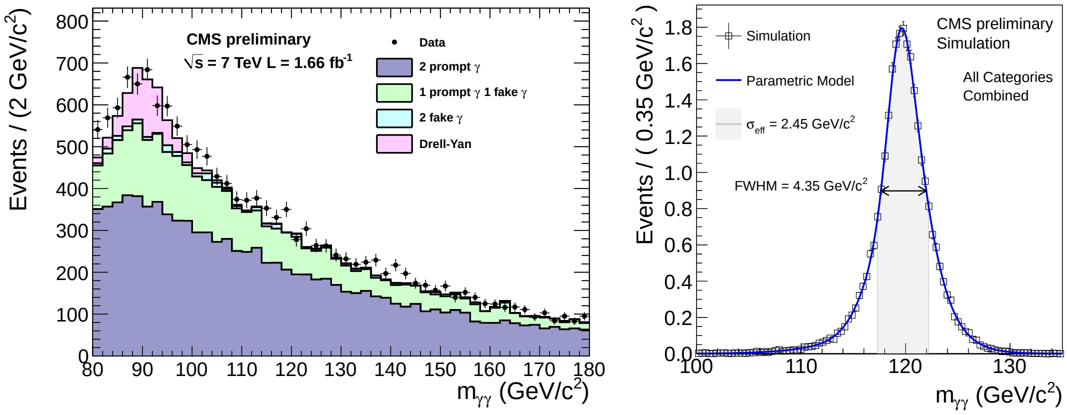

Figure 1: Left: Diphoton mass distribution for data and Monte Carlo simulation of SM background processes. Right: simulated signal (m_H=120 GeV) for all 8 event classes combined.

within uncertainties (about 15% in the normalization). This is shown in Fig. 1, demonstrating how good is the understanding of photon efficiency and misidentification rates.

The reconstruction of the diphoton invariant mass is affected by a limited measurement of the energy scale and resolution of the ECAL. Presently, the resoluton is degraded by the not yet optimal corrections for transparency loss and material bugdet. To precisely determine the performance of the ECAL a sample of $Z \to ee$ is used. Detailed studies of the ee invariant mass compared with the MC simulation allow for a tuning to correct the measured energy of the photons. Once this tuning is determined, the photon energy is smeared on MC to match the data. The expected signal shape for the Higgs candidates selected in the analysis, after the application of the smearings, is shown in Fig. 1. The $m_{\gamma\gamma}$ resolution depends on whether the photon is detected in the barrel or in the endcap, whether it converted or not, and on the p_T of the Higgs candidate. In the best category (both photons in barrel with R9>0.94 and $p_T(\gamma\gamma) > 40$ GeV) the FWHM is about 2.85 GeV. This performance in the resolution of the diphoton invariant mass can be preserved only by correctly assigning the reconstructed photons to one of the interaction vertices reconstructed from the charged tracks. The vertex is identified by using the information on the kinematics of the tracks associated with the vertex and their correlation with the diphoton kinematics. In addition, in case one of the two photons converts and a conversion track is reconstructed, its direction is used to point to the Higgs boson interaction. The efficiency of the method in data has been studied with $Z \to \mu\mu$ events where the algorithm is run after the removal of the muons.

The sensitivity of the search depends on mass resolution and signal to background ratio. It can be then increased by subdividing the events into classes where mass resolution and signal to background ratio are different. The variables used to define these 8 classes are the minimum R9 and the maximum pseudorapidity of the two photons, and p_T of the diphoton system. Classifying in R9 and pseudorapidity separate diphotons with good resolution and higher signal to background ratio. The main benefit from the momentum classification is the sensitivity it gives to the fermiophobic model where the only production processes allowed result in Higgs bosons with significant p_T.

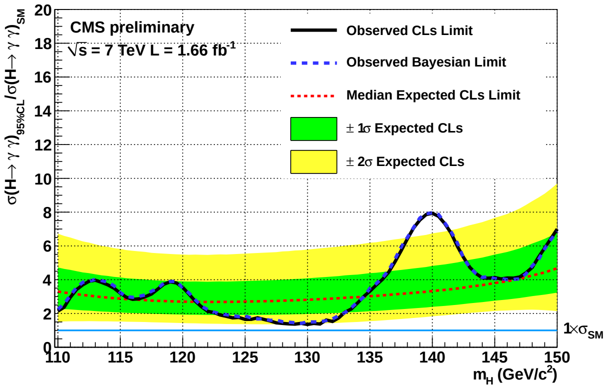

Figure 2: Exclusion limit on cross section of a SM Higgs boson relative to the SM cross section as a function of the boson mass.

3. Limit extraction and results

The background is modeled by fitting the observed diphoton mass distributions in each of the 8 event classes with 2^{nd} order Bernstein polynomials over the range $100 < m_{\gamma\gamma} < 160$ GeV. The confidence level (CL) for exclusion or discovery is evaluated using the diphoton invariant mass distribution as the observable for each event class. The results in the classes are combined in the CL calculation to obtain the final result. The signal model is taken from the MC after applying the energy smearing described above. The systematics uncertainties are taken into account in the limit setting. The largest contributions are due to the uncertainty on the integrated luminosity and to the uncertainties on the Higgs cross section from theory.

Since there is no significant excess, a 95% CL limit is extracted on the cross section of a Higgs boson decaying to 2 photons relative to the SM expectation. This is shown in Fig. 2. The observed limits are consistent with the expected ones within statistical fluctuations. With 1.66 fb^{-1} there is no exclusion yet and the expected exclusion limit is between 2.7 and 4.7 times the Standard Model cross section. These results give the most stringent limits for very low masses ($m_H < 130 GeV$) in the CMS combination [6]. The limit is also extracted in the fermiophobic model, where the branching fraction to a photon pair is much larger for very low masses and the Higgs boson has a harder p_T spectrum. In this scenario, the expected exclusion limit covers the mass range between 110-116.5 GeV, while the data excludes only the mass range 110-112 GeV.

References

[1] M. Baak *et al.*, arXiv:1107.0975 [hep-ph].

[2] CDF Collaboration, Phys. Rev. Lett. **103** (2009) 061803, doi:10.1103/PhysRevLett.103.061803.

[3] D0 Collaboration, Phys. Rev. Lett. **102** (2009) 231801, doi:10.1103/PhysRevLett.102.231801.

[4] CMS collaboration, CMS-PAS-HIG-11-021 (2011).

[5] CMS Collaboration, JINST **03 (2008) S08004** (2008). doi:10.1088/1748-0221/3/08/S08004.

[6] CMS collaboration CMS-PAS-HIG-11-022 (2011).

PoS(EPS-HEP2011)247