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Search for the Standard Model Higgs boson decaying into two photons with the CMS experiment

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Summary. — With the discovery of a Higgs boson, the standard model (SM) of particle physics has been successfully proved giving an answer to the origin of the masses issue, through the electroweak symmetry breaking mechanism. The Higgs decaying to two photons is presented. Although this process has a low branching ratio, it provides a clean final state topology, with a peak that can be observed over the background. The analysis is performed using 2011 and 2012 datasets recorded by the the CMS experiment [1] from pp collisions at centre of mass energies of 7 TeV (5.1/fb) and 8 TeV (19.6/fb) and shows the presence of a new boson with a mass of about 125 GeV.

PACS 14.80.Bn – Standard-model Higgs bosons.

In 2012, the ATLAS and CMS Collaborations observed a new particle with properties compatible with the ones of the SM Higgs boson [2, 3]. We present here the results concerning the observation of the Higgs boson in its decay to two photons [4, 5]. The study of main production modes at LHC are included: gluon-gluon fusion, vector boson fusion and associated production with a W or a Z boson or a $t\bar{t}$ pair.

Photon candidates are initially reconstructed from energy deposits in the electromagnetic calorimeter (ECAL). Then, after a preselection, a Boosted Decision Tree (BDT) [6] is applied, to distinguish prompt photons from non-prompt photons, using shower topology variables and isolation variables. The photon energy is computed starting from the raw supercluster energy from the ECAL and corrections are implemented through a multivariate regression. The diphoton mass resolution is affected by the diphoton vertex measurement, so that a BDT for vertex position is constructed using variables based on transverse momentum (p_T) of tracks associated to the vertex, the $p_T^{\gamma\gamma}$ and conversions informations. Finally a multivariate discriminator is used to select events with high probability to come from signal and with good mass resolution. This discriminator is constructed using diphoton and vertex informations. To achieve the best performance, after the selection of the diphoton system, the events are classified in categories that exploit the production modes and that have different signal over background ratio. Several systematic uncertainties have been evaluated: the energy scale and resolution for the

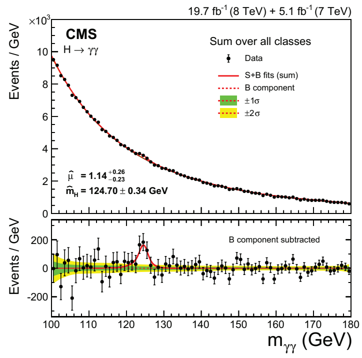

Fig. 1. – Invariant mass of the two photons for all the events selected by the different categories of the analysis at 7 and 8 TeV.

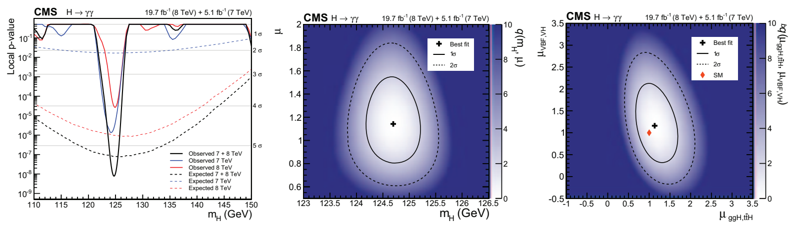

Fig. 2. – Local p-value (left); results for the measurement of the Higgs mass m_H and of the best fit signal strength μ (center); and measurement of the two signal strengths $\mu_{ggH,t\bar{t}H}$ and $\mu_{VBF,VH}$ that are sensitive to different couplings of the Higgs boson (right).

photons, photon identification (preselection and BDT), vertex finding efficiency, trigger efficiency, theoretical production cross sections and uncertainty due to the additional objects in the exclusive categories (jet, leptons and missing energy).

The invariant mass of the diphoton system for all the events selected by the different categories and for both 7 and 8 TeV analysis is shown in fig. 1. The lower plot shows the excess of events due to the presence of the Higgs boson, after the subtraction of the background.

The observed local p-value is 5.7σ at a measured mass of 124.7 ± 0.34 GeV, as shown in fig. 2. The signal strength $\mu = \sigma/\sigma_{SM}$ is $1.14^{+0.26}_{-0.23}$, while if the couplings of the Higgs boson to fermions and to vector bosons are considered separately, the signal strengths are $\mu_{ggH,t\bar{t}} = 1.13^{+0.37}_{-0.31}$ and $\mu_{VBF,VH} = 1.16^{+0.63}_{-0.58}$.

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