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Study of associate production of the Higgs boson in the diphoton decay channel at the CMS experiment

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Summary. — The observation of a boson compatible with the Standard Model (SM) Higgs particle is the starting point for the complete understanding of the electroweak symmetry-breaking mechanism. More specifically, the exact determination of the Higgs couplings to bosons and fermions is crucial to establish if the properties of this particle are compatible with the theoretical predictions. In order to achieve a good sensitivity in couplings measurements it is important to consider those production modes where the Higgs boson is produced in association with W/Z bosons or quarks. The characteristic topology of these events allows to perform an exclusive analysis, crucial for accurate measurements of couplings.

PACS 14.80.Bn – Standard-model Higgs bosons.

1. – Associate production of the Higgs boson in the diphoton decay channel

The Higgs boson is a fundamental particle predicted by the SM theory, responsible for giving mass to the other particles. The CMS [1] experiment in 2012 reported the discovery of a new boson compatible with the SM Higgs. In order to understand the nature of this new boson, the exact determination of the Higgs couplings to bosons and fermions is crucial; indeed the value of the couplings can be predicted by the theory and their measurements could prove or deny these predictions.

To increase the sensitivity of the searches, it is important to search for associate production of the Higgs with other particles, such as quarks and vector bosons. These production modes have a lower cross section with respect to gluon-gluon fusion (ggH), which is the main production mechanism, but the possibility to tag other objects with a specific topology in the final state allows us to significantly improve the signal over background ratio. The production modes analyzed are vector boson fusion (VBF) and associate production with vector bosons (VH). VBF production mode is characterized by the presence of two forward jets at high pt in the final state. In the VH channel, instead, the main feature is the presence of isolated leptons or missing transverse energy due to leptonic decays of the vector boson (W or Z). Two different exclusive categories are implemented for VBF, according to tighter or looser kinematic cuts, while the VH channel is splitted in three categories (electron, muon and MET) to catch different decays of the vector boson.

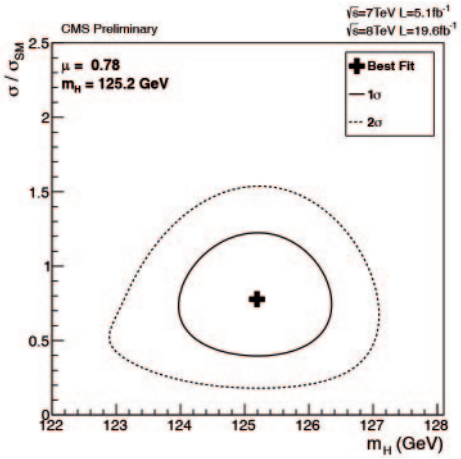

Fig. 1. – Measured signal strength for different production mechanisms.

The analysis is performed in the diphoton decay channel. Despite the low branching ratio ($\sim 2‰$ for a 125 GeV Standard Model Higgs Boson), this decay mode is one of the most sensitive because of its very clean final state, with a reasonable signal over background ratio. In this channel we expect a narrow peak over a falling distribution for the diphoton invariant mass ($M_{\gamma\gamma}$) spectrum, so it is crucial to have a good resolution in measuring photon energy and to identify correctly the vertex of the interaction. The energy of photons from the Higgs decay can be measured with a precision of better then 1% in the CMS experiment and the vertex is assigned correctly in $\sim 80\%$ of events also at high pile-up.

These exclusive categories have lower statistics compared to the untagged one but a very good signal over background ratio (ranging from ~ 1 in the VH MET tag to ~ 2.5 for the VBF tight tag).

2. – Conclusion

Including associate production modes in the search of the Higgs boson allows to increase statistical sensitivity in the diphoton channel [2]. A new boson is now observed with a significance of 3.2 sigma (4.2 exp) with a mass $m_H = 125.4 \pm 0.5(\text{stat}) \pm 0.6(\text{syst})$ GeV.

The measured signal strength is compatible with respect to SM prediction: $\sigma = 0.78 \pm 0.27$ using the full dataset collected in 2011 and 2012.

As can be seen in fig. 1 exclusive channels allows to decouple measurement of signal strength in different production modes. We can measure signal strength for gluon-gluon fusion and ttH ($\mu_{ggH+ttH}$) and for VBF and VH production mechanism (μ_{VBF+VH}) separately. The measured values are $\mu_{ggH+ttH} = 0.52$ and $\mu_{VBF+VH} = 1.48$.

REFERENCES

[1] CMS Collaboration, *JINST*, **3** (2008) S08004.
[2] CMS Collaboration, *Updated measurements of the Higgs boson at* 125 GeV *in the two photon decay channel*, CMSPAS-HIG-13-001.