IL NUOVO CIMENTO **41 C** (2018) 18
DOI 10.1393/ncc/i2018-18018-7

COLLOQUIA: IFAE 2017

Study of the production modes of the Higgs boson and EFT interpretations in the $H \to ZZ^* \to 4l$ decay channel at 13 TeV center-of-mass energy with the ATLAS detector at LHC

G. MANCINI

INFN LNF - Frascati (RM), Italy

received 21 April 2018

Summary. — After the Higgs boson discovery, great interest was given to the measurements of its properties and studies have been performed to test its nature and probe whether it is the Standard Model (SM) Higgs boson or not. The first measurements performed during Run2 at LHC have been oriented on the measurements of the Higgs boson properties. In this context, studies are performed in order to measure the cross-section per production mode in reduced phase spaces enriched in each production mode via a categorization of the events in the signal region. The same categorization has shown a good sensitivity to Beyond Standard Model couplings related to additional Effective Field Theory contributions to the Standard Model Lagrangian. Results are shown in the $H \to ZZ^* \to 4l$ decay channel with data corresponding to $14.8\,\text{fb}^{-1}$ at 13 TeV recorded by ATLAS at LHC.

1. – Analysis description

Higgs boson candidates are formed by selecting two same-flavour, opposite-sign lepton pairs (a lepton quadruplet) in an event.

The background is composed by an irreducible ZZ^* component (estimated from MC) and a reducible Z + jets and $t\bar{t}$ component estimated from data using enriched Control Regions. Cross-section measurements per production mode are extracted via a categorization of the events based on the topology of the Higgs events looking at the number of jets associated to the events and the presence of an additional lepton (fig. 1).

Dedicated discriminants have been built in each category to gain in discrimination power between the production modes (no discriminants in the VH-leptonic category used, due to the small number of events expected).

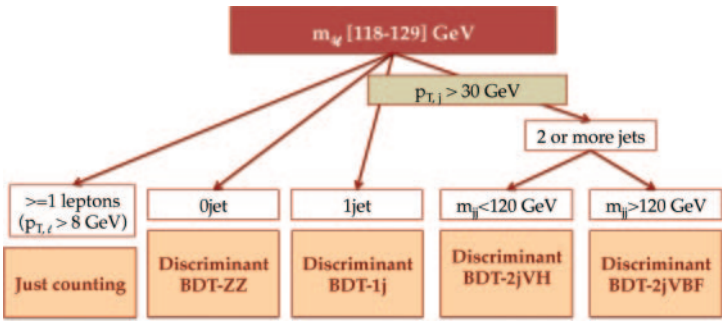

Fig. 1. – Categorization of the signal events in the $H \to ZZ^* \to 4l$ decay channel.

The observed number of events in each analysis categories (N_k^{obs}), can be expressed as

$$N_k^{obs} = \mathcal{L}_{int} \times \mathcal{BR}_{H\to ZZ^*\to 4l} \times \left(\sum_{i=1}^{N^{prod}} \sum_{j=1}^{N_{bin}^i} A_{kj}^i \sigma_i^j \right),$$

where $\mathcal{L}_{int}$ is the integrated luminosity, N^{prod} the number of Higgs production mechanisms, N_{bin}^i is the number of truth bins per Higgs production mechanism (i), A_{kj}^i the detector response (trigger, reconstruction and identification efficiencies) for detecting the final state and the kinematic and geometric acceptance for the truth bin j of the Higgs production mechanism i in the analysis category k.

2. – EFT terms in the SM Lagrangian

The possible presence of BSM terms in the Lagrangian describing the spin-0 resonance is investigated describing the HVV vertex interaction in terms of an effective BSM CP-odd and CP-even operators and deriving limits on the corresponding BSM couplings [1]. The κ_{SM}, κ_{HVV} and κ_{AVV} denote, respectively, the coupling constants corresponding to the interaction of Standard Model, BSM CP-even and BSM CP-odd spin-0 particles, represented by the X^0 field, with ZZ or WW pairs.

The tensor couplings have been studied separately, fixing in the Lagrangian the SM component to its expectation ($\kappa_{SM} = 1$) and without considering discriminants in categories.

3. – Results

The measured cross-sections per production mode have been found to be in agreement within 1.5 σ level with the SM expectations [2]:

$$\sigma_{ggH+t\bar{t}H+b\bar{b}H}\mathcal{BR}(H \to ZZ^*) = 1.80^{+0.49}_{-0.44} \text{ pb} \qquad \sigma_{VBF}\mathcal{BR}(H \to ZZ^*) = 0.37^{+0.28}_{-0.21} \text{ pb}.$$

A 2-dimensional plot of the measured cross-section per production mode is reported in fig. 2 together with the interpretations of the results within the κ framework, using the coupling constants κ_F and κ_V respectively for the cross-sections mediated by fermions and vector bosons [2]. Limits on BSM values give that the agreement with the SM expectation is at the 2 σ level as shown in fig. 3 [2].

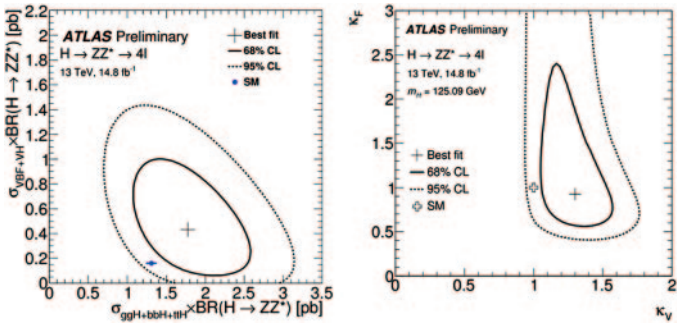

Fig. 2. – Left: negative log-likelihood contours at 68% (solid line) and 95% CL (dashed line) in the $\sigma_{ggF+b\bar{b}H+t\bar{t}H}\mathcal{BR}(H \to ZZ^*)$-$\sigma_{VBF+VH}\mathcal{BR}(H \to ZZ^*)$ plane together with the SM predictions (blue point); the relative contribution of the VBF and VH production modes has been assumed to follow the SM prediction. Right: the likelihood contours at 68% CL (solid line) and 95% CL (dashed line) in the κ_V-κ_F plane derived from the event categorization results.

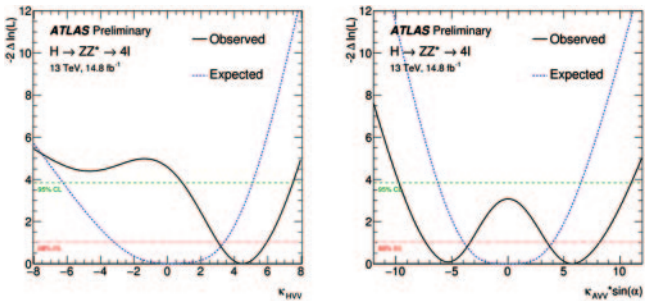

Fig. 3. – Negative log-likelihood scans for κ_{HVV} (left) and $\kappa_{AVV}\sin\alpha$ (right). The horizontal red and green dashed lines indicate, respectively, the 68% and 95% CL intervals for the parameter of interest.

4. – Conclusions

Measurements performed up to now (still statistically limited) show results compatible with the SM predictions and with comparable sensitivity with respect to Run1.

REFERENCES

[1] Artoisenet P. *et al.*, *JHEP*, **11** (2013) 043.
[2] The ATLAS Collaboration, *Study of the Higgs boson properties and search for high-mass scalar resonances in the* $H \to ZZ^* \to 4l$ *decay channel at* $\sqrt{s} = 13$ *TeV with the ATLAS detector* (ATLAS-CONF-2016-079, 4 August 2016).