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Multi-boson electroweak physics at CMS

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Summary. — The precision measurement of multi-boson processes at the Large Hadron Collider is a fundamental test of the consistency of the Standard Model and can hint at effects of new physics. In this note, the most relevant results obtained in multi-boson processes by the CMS experiment at a centre of mass energy of 13 TeV are presented with particular focus on the results interpretation in the framework of Effective Field Theories.

1. – Introduction

The precision measurement of multi-boson electroweak processes is important in many different ways. The measurement of the production cross section constitutes a precision test of the Standard Model (SM) since it is sensitive to the self-interaction of electroweak bosons. This final state is also one of the possible backgrounds sources in the searches for new particles that can mediate multi-boson interactions and hence must be studied in detail. Moreover, multi-boson processes are sensitive to the presence of anomalous gauge couplings and can probe the presence of effects that are beyond the Standard Model.

Studies of the anomalous gauge couplings can be performed in the Effective Field Theory (EFT) framework. The SM Lagrangian can be expanded including terms with dimension higher than four,

$$\mathcal{L}_{aGC} = \mathcal{L}_{SM} + \sum_i \frac{f_i}{\Lambda^{d-4}} O_i + \cdots , \tag{1}$$

where O_i is the operator that modifies the Lagrangian, Λ is the energy scale of the new physics, d is the dimension of the operator and f_i are the Wilson coefficients which are linked to the strength of the new coupling. By measuring the cross sections and event yields in certain regions of the phase space in multi-boson production processes, the value of the Wilson coefficients normalised to the energy scale can be determined and, if found to be different from zero, can hint at the presence of new physics.

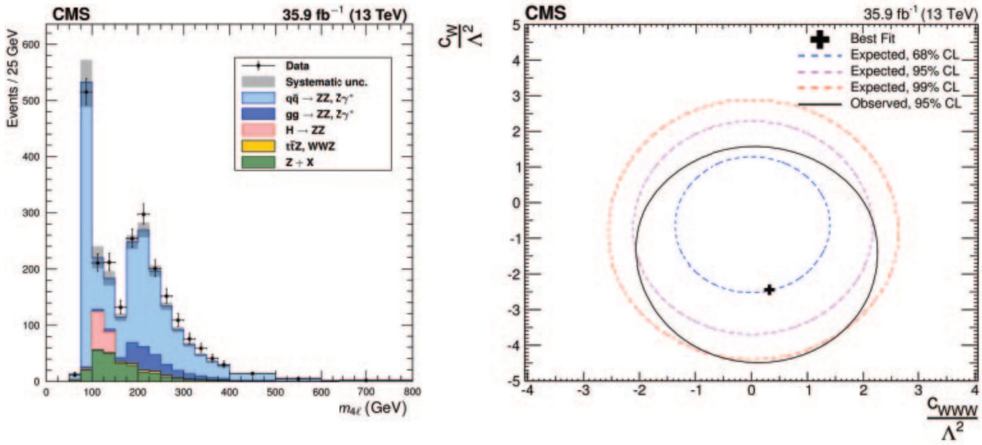

Fig. 1. – Four-lepton invariant mass for the ZZ production (left), limits on WWZ anomalous couplings (right).

2. – Di-boson studies: WW, WZ, ZZ

Beyond the Standard Model (BSM) theories allow the existence of particles that could decay in final states with two electroweak bosons. The precise determination of the di-boson cross sections is therefore of major importance in searches for new particles. The ZZ production [1], for example, provides a clean final state in the 4-lepton decay channel and is both a background in Higgs studies and searches of new particles. The good description of the process (see fig. 1, left) allows a determination of the cross section with a small uncertainty and hence a higher precision for future Higgs and BMS measurements. Moreover, di-boson processes are sensitive to the strength of triple boson couplings. The associate production of a W and a Z boson [2], for example, is sensitive to the strength of the WWZ coupling with a Z boson in the final state. The limits obtained in this analysis in a region of high di-boson mass (where the anomalous coupling effect is maximised) are the most stringent on the WWZ coupling (see fig. 1, right).

3. – Same-sign WW

Extensions of the SM allow the existence of charged Higgs-like particles. If these particles do exist, a possible decay channel would be the one with two W bosons with same sign in the final state. The first observation of the production of same-sign W bosons in the electroweak channel [3] has been performed by the CMS Collaboration. From this analysis, the ratio of the measured event yield compared to the SM one has been measured to be 0.90 ± 0.22. The measurement shows no deviations from the SM prediction, however limits on the strength of the WWWW couplings and on the mass of the double-charged Higgs have been extracted.

REFERENCES

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[3] The CMS Collaboration, *Phys. Rev. Lett.*, **120** (2018) 081801.