PROCEEDINGS OF SCIENCE

Search for heavy scalar resonances in the 4-lepton final state at CMS

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A search for heavy scalar resonances decaying to a pair of Z bosons in the 4-lepton final state is presented, with the data collected by the CMS detector from 2016 to 2018 at center-of-mass energy of 13 TeV, corresponding to an integrated luminosity of 138 fb^{-1}. A model-independent approach is applied to model signal, background and interference processes. Large mass region is covered from 130 GeV to 3 TeV, and different width assumptions and production mechanisms are tested. No significant excess is observed, and upper limits on the production cross section of the resonance multiplied by its decay branching ratio of decaying into two Z bosons at 95% confidence level are computed.

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1. Introduction

The discovery of the Higgs boson has indicated the great success of the Standard Model (SM), which nevertheless still has some limitations. Theories beyond the SM (BSM) have been raised to resolved remaining issues, and many of them predicts new resonances, e.g. the additional Higgs boson in the two-Higgs-doublet model [1].

This poster presents the recent results [2] published by the CMS Collaboration, to search for heavy scalar resonances (X) decaying into two Z bosons in the four-lepton final state, with leptons being electrons or muons. The Run 2 data collected by the CMS detector [3] from 2016 to 2018 is used, corresponding to an integrated luminosity of 138 fb^{-1}. The examined mass range of the new resonance M_{X} is from 130 GeV to 3 TeV, with various decay width assumptions. The resonance is assumed to be produced via gluon fusion (ggF) or vector boson fusion (VBF).

2. Analysis strategy

Events should firstly fire the lepton triggers. Reconstructed electrons and muons are selected with dedicated kinematic requirements, identification and isolation criteria, and are used to build the Z boson candidates and ZZ candidates. Events are categorized based on the topologies of additional jets and the variable computed using the Matrix Element Likelihood Approach (MELA) [4, 5], to improve the sensitivity to VBF signals.

A model-independent approach is used to construct the statistical model. Two variables are used to discriminate signals from backgrounds: the 4-lepton mass, and a kinematic discriminant built from MELA. The interferences are modeled based on the amplitudes of signals and backgrounds, as well as phases from theoretical calculations.

3. Results

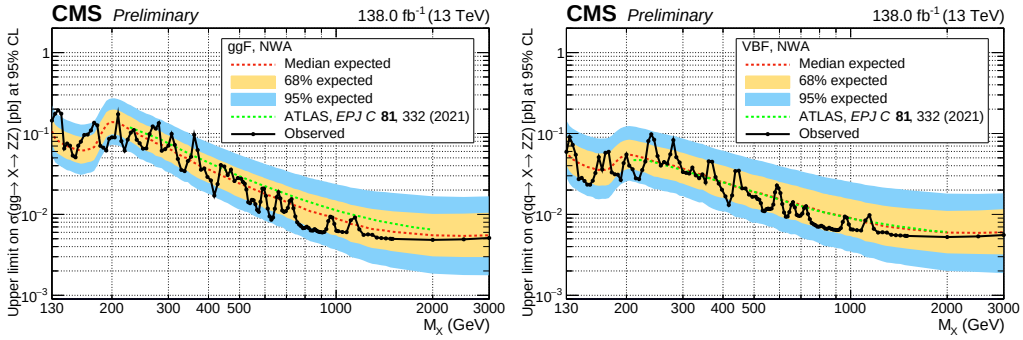

Figure 1: Upper limits on $\sigma(\text{pp} \to \text{X} \to \text{ZZ})$ at 95% confidence level as a function of M_{X}, with narrow width assumption, produced via ggF (left) or VBF (right).

No significant excess is observed in data with respect to the SM expectation. Upper limits on the production cross section multiplied by the decay branching ratio ($\sigma(\text{pp} \to \text{X} \to \text{ZZ})$) at 95% confidence level are computed. Figure 1 shows the results for narrow width assumption (the width Γ_{X} =4.1 MeV), produced via ggF or VBF. The upper limits range from 0.005 to 0.2 pb.

Observed results are mostly within the ±2 standard deviation band of expected ones. The highest excess is reached at 137.8 GeV, with a local (global) significance of 3.02 (1.85) σ. Compared to the ATLAS experiment [6], the expected limits are more stringent with the ggF production, and comparable with the VBF production.

Various width assumptions are tested. An example is shown in Figure 2, where Γ_X ranges from narrow width to $0.3M_X$. Observed results are in general compatible with the expected ones.

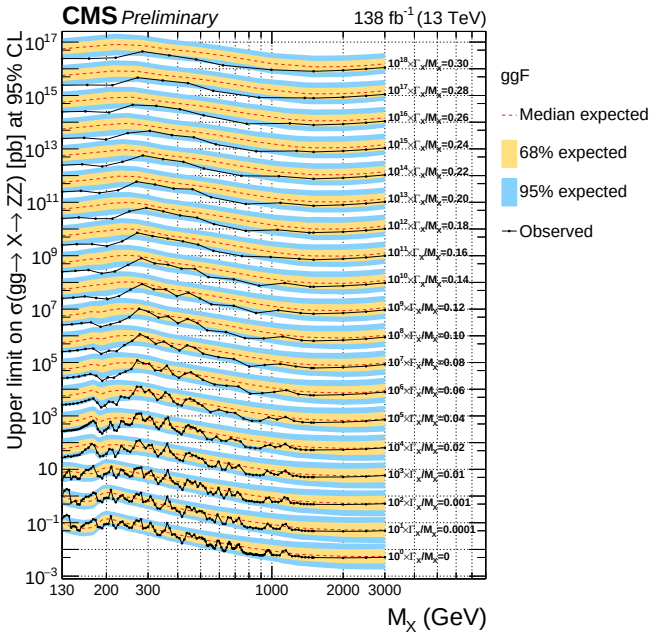

Figure 2: Upper limits on $\sigma(\mathrm{pp} \to \mathrm{X} \to \mathrm{ZZ})$ at 95% confidence level as a function of M_X, with various width assumptions, produced via ggF.

4. Summary

Searches for a scalar resonance decaying to a pair of Z bosons in the 4-lepton final state are performed using the full Run 2 dataset collected with the CMS detector. With a mass range from 130 GeV to 3 TeV and various width assumptions, no significant excess is observed with respect to the background-only hypothesis. Upper limits at 95% confidence level on the production cross section multiplied by the decay branching ratio of $\mathrm{X} \to \mathrm{ZZ}$ are computed. The observed results are in general compatible with the expected ones.

References

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