PROCEEDINGS OF SCIENCE

Higgs boson searches beyond the Standard Model

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1. Introduction

test

2. Search for neutral Higgs bosons $H/A \to \tau\tau$

3. Search for Higgs boson pair production

The Higgs boson pair production could be use to investigate both the SM and the BSM scenarios.
Searches for *non-resonant hh* production give information on the trilinear coupling present in the SM Higgs potential fields; the same searches could spot out discrepancies with respect to the SM λ_{hhh} introduced by anomalous couplings and new physics.
Similar searches in the *resonant* regime could be used to explore the BSM world; new particles, introduced by extensions in the $\mathscr{L}_{SM}$, could decay in a couple of Higgs SM like boson (Di-Higgs). The experience acquired during the $8\,TeV$ data taking period at LHC for SM Higgs search is used for seek different final state configuration of the Di-Higgs.

In this paragraph an overview of the latest *resonant* results, provided by ATLAS and CMS experiment for $13\,TeV$ collision, will be presented. Both collaboration have produced results with $8\,TeV$ data [1][2] in many Di-Higgs decay configurations as shown in figure 1.

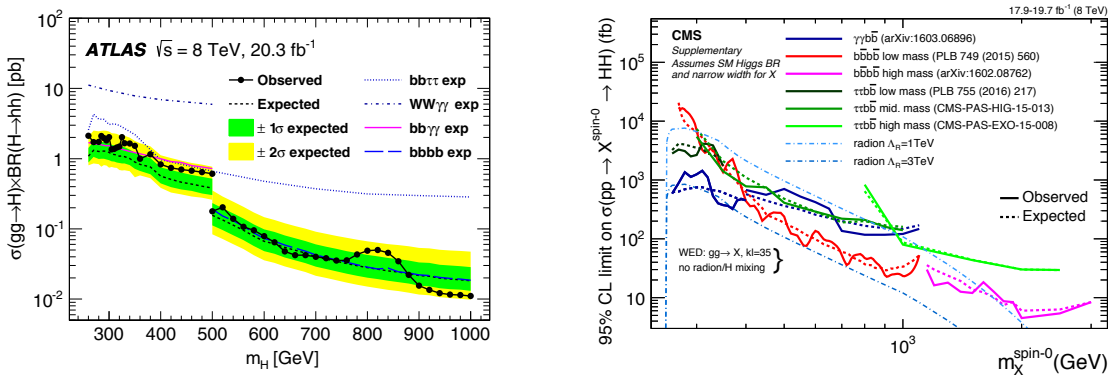

Figure 1: (left) ATLAS combination Higgs boson pair production in the $hh \to bb\tau\tau$, $\gamma\gamma WW^*$, $\gamma\gamma bb$, $bbbb$ channels with $8\,TeV$ data, (right) CMS Observed and expected 95% CL upper limits on the product of cross section and the branching fraction $\sigma(gg \to X) \times B(X \to hh)$ obtained by different analyses assuming spin-0 hypothesis.

3.1 $H \to hh \to bbbb$ channel

The Higgs boson decay mode in b quarks has the highest branching ratio, this imply that a Di-Higgs final state, with each Higgs dacaying into a b pair, it's the most prominent one between the others. Although search of this kind of final state should take into account the overwhelming multi-jet background, largely produced at hadrons collider.

ATLAS and CMS collaborations analysis scan a mass range $260\,GeV < m_H < 3000\,GeV$, particularly CMS cover from $260\,GeV$ to $1200\,GeV$ and ATLAS from $500\,GeV$ to $3000\,GeV$. Both analysis have different strategy for different m_H ranges: low-mass region ($260\,GeV < m_H < 400\,GeV$), medium-mass ragion ($400\,GeV < m_H < 1200\,GeV$), boosted region ($1200\,GeV < m_H < 3000\,GeV$). The categorisation is chosen to maximise to significance of the analysis.

The results are shown in figure 2.

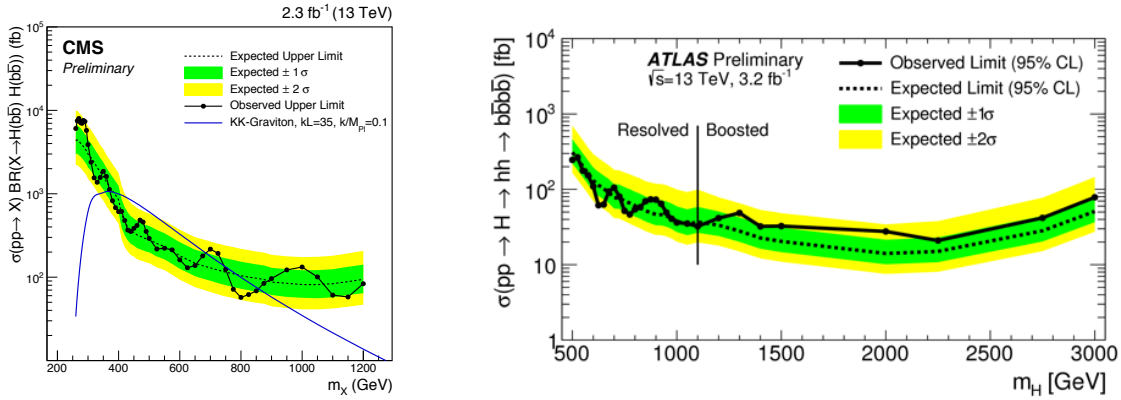

Figure 2: (left) CMS: The observed and expected upper limits on the cross section for a spin-2 resonance $H \to hh \to bbbb$ at a 95% confidence level using data corresponding to an integrated luminosity of $2.3 fb^{?1}$ at $13TeV$ using the asymptotic CL_S method, (right) ATLAS: The expected and observed upper limit for $pp \to H \to hh \to bbbb$ with fixed $\Gamma_H = 1GeV$, at the 95% confidence level .

3.2 $H \to hh \to bb\tau\tau$ channel

The $bb\tau\tau$ channel can exploit the presence of the τ leptons to take care of the multi-jet background.

The analysis performed by CMS collaboration scans a $260\,GeV < m_H < 900\,GeV$ and combine three different $\tau\tau$ final state: $\mu\tau_h$, $e\tau_h$ and $\tau_h\tau_h$, where τ_h stands for the hadronic decays of a τ. The finale m_H shape is constructed using a dedicated kinematic fit procedure.

Observed and expected 95% CL upper limits are shown in figure 3.

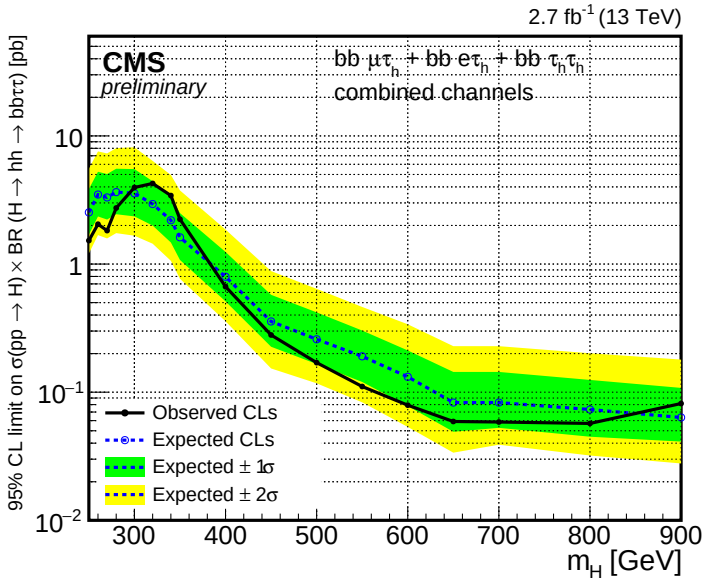

Figure 3: Observed and expected 95% CL upper limits on $\sigma(pp \to H) \times BR(H \to hh \to bb\tau\tau)$ from the combination of the three channels as a function of the mass of the resonance m_H

3.3 $H \to hh \to bbWW$ channel

The search for resonant Higgs pair production, $H \to hh$, where one of the h decays as $h \to bb$, and the other as $H \to WW \to l?l?$ (where l is either an electron or a muon) is performed by CMS collaboration using LHC proton-proton collision data at $13\,TeV$. The analysis focuses on the invariant mass distribution of the b-jet pair, searching for a resonant-like excess compatible with the h boson mass in combination with a boosted decision tree discriminant based on kinematic information. The dominant background is tt production with smaller contributions from Drell-Yan and single top processes. Figure 4 shows the result obtained.

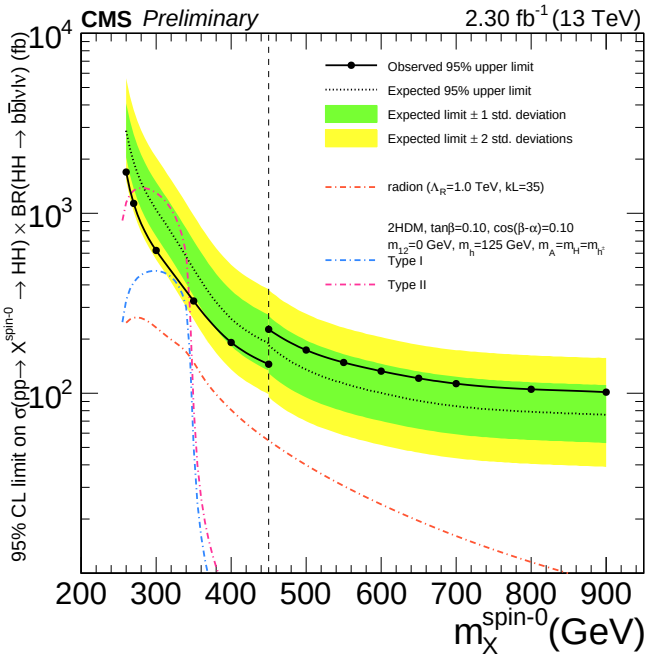

Figure 4: Observed and expected 95% CL upper limits on $\sigma(pp \to H) \times BR(H \to hh \to bbl\nu l\nu)$

3.4 $H \to hh \to bb\gamma\gamma$ channel

The $bb\gamma\gamma$ final state is particularly promising for the DiHiggs search, as it benefits from the large branching fraction of the $h \to bb$ decay and the clean di-photon signal, due to high $m_{\gamma\gamma}$ resolution, on top of a smooth continuum di-photon background from multi-jet and multi-photon SM processes.

The analysis performed by ATLAS collaboration scans masses in the range $275GeV < m_H < 400GeV$. A counting approach is adopted in order to estimate the number of signal and background events.

Observed and expected 95% CL upper limits are shown in figure 5.

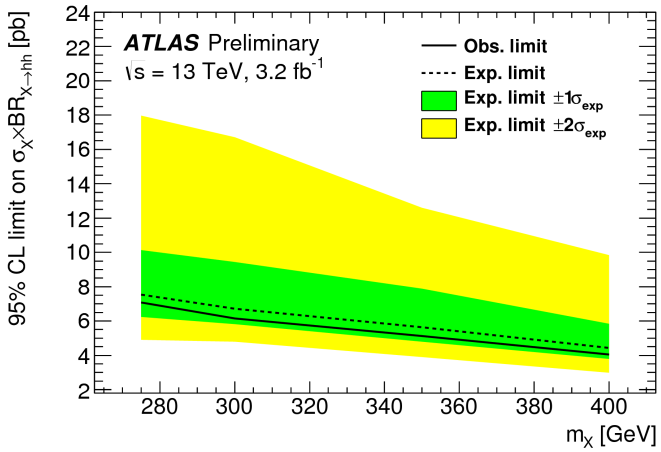

Figure 5: Observed and expected 95% CL upper limits on $\sigma(pp \to H) \times BR(H \to hh \to bb\gamma\gamma)$

4. Conclusions

References

[1] ATLAS Collaboration. *Searches for Higgs boson pair production in the $hh \to bb\tau\tau$, $\gamma\gamma WW^*$, $\gamma\gamma bb$, bbbb channels with the ATLAS detecto.* 10.1103/PhysRevD.92.092004, Phys. Rev. D, American Physical Society, 2015

[2] *https://twiki.cern.ch/twiki/bin/view/CMSPublic/SummaryResultsHIG.*

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