



Search for nonresonant Higgs boson pair production in final states with a pair of b-quarks and a pair of photons in $\sqrt{s} = 13$ TeV pp collisions data at CMS experiment

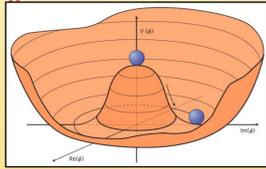
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Introduction

- Shape of the Higgs potential depends on (trilinear Higgs coupling) λ_{HHH} , m_H (Higgs mass) and v (vacuum expectation value)
- Measuring λ important because it probes the shape of the Higgs potential
- HH production at the LHC provides direct access to λ



- GGF & VBF → Leading and sub-leading modes
 - GGF cross-section: 31.05 fb^{-1}
 - VBF cross-section: 1.73 fb^{-1}
- BR ($HH \rightarrow 2b2\gamma$): 0.26 %
- Despite of small BR, $H \rightarrow \gamma\gamma$ good mass resolution → CMS ECAL
Easy to detect over continuum backgrounds

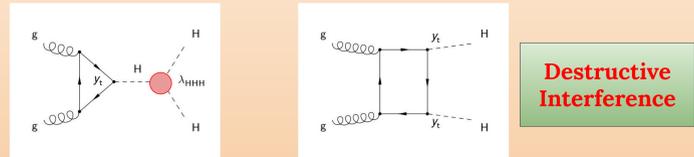
In SM :

$$\lambda_{HHH} = \lambda_{HHHH} = \frac{m_H^2}{2v^2} = 0.13$$

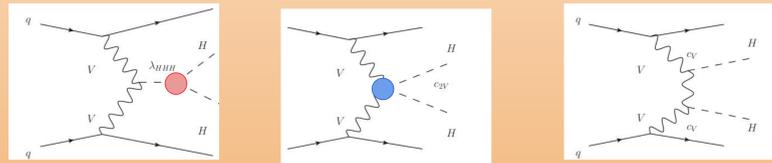
- Contribution backgrounds
 - Non-resonant backgrounds: $\gamma\gamma + \text{jets}$, $\gamma + \text{jets}$, $tt + X$
 - Resonant backgrounds: single $H \rightarrow \gamma\gamma$
- Among the H production modes (ttH) has the largest contributions

Feynman diagrams

Gluon-Gluon Fusion (GGF)



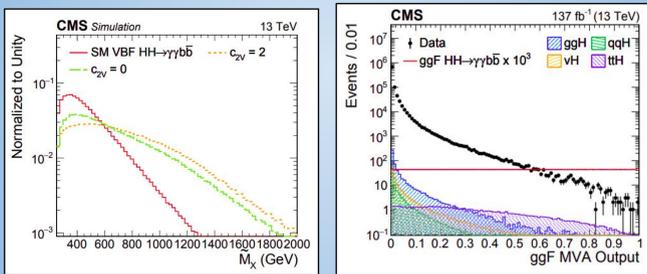
Vector Boson Fusion (VBF)



- VBF $HH \rightarrow$ probes the direct coupling between a pair of Higgs boson with a pair of Vector bosons (C_{2V})
- The coupling parameters are measured in κ - framework

Analysis Strategy

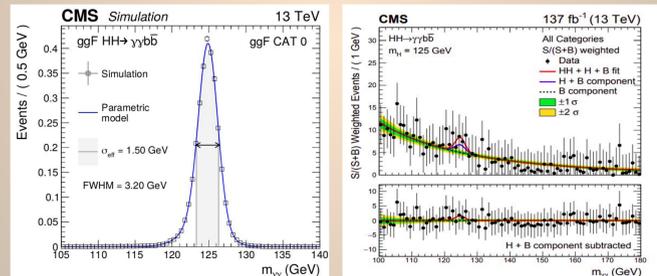
- Mutually exclusive event selections for VBF HH and GGF HH
- Multivariate analysis (MVA) techniques used to separate background contamination
- Further categorization based on MX ($M_{\gamma\gamma b\bar{b}} - M_{\gamma\gamma} - M_{b\bar{b}} + 250 \text{ GeV}$) and MVA output score



- MX ~ sensitive to probe beyond the standard model (BSM) physics
MVA helps in signal purity

Signal and background modelling

- 2D parametric model of $m_{\gamma\gamma}$ and $m_{b\bar{b}}$ has been used
- Signal and resonant background modelling:
 - $m_{\gamma\gamma}$: multi Gaussian fit
 - $m_{b\bar{b}}$: Double Sided Crystal Ball (DSCB) function
- Non-resonant background is directly modelled from Data
Discrete profile method used
F-Test → determines the polynomial function and its order



- Final signal extraction performed by simultaneous fit to all categories

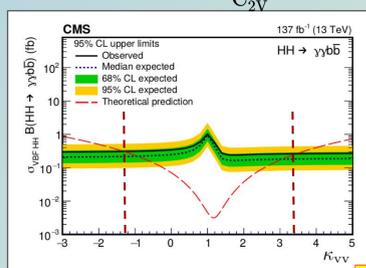
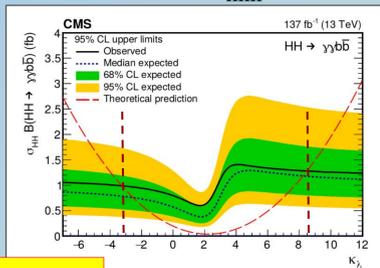
Results

- Upper limit on inclusive HH cross section * BR @ 95% CL in terms of SM predicted value

Observed	7.7
Expected	5.2

$$\kappa_\lambda = \frac{\lambda_{HHH}^{obs}}{\lambda_{HHH}^{SM}}$$

$$\kappa_{VV} = \frac{C_{2V}^{obs}}{C_{2V}^{SM}}$$



Best-to-date in CMS

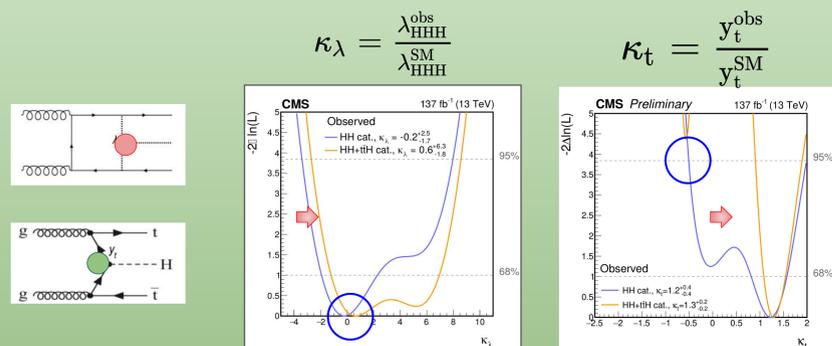
Observed: $-3.3 < \kappa_\lambda < 8.5$
Expected: $-2.5 < \kappa_\lambda < 8.2$

Observed: $-1.3 < \kappa_{VV} < 3.5$
Expected: $-0.9 < \kappa_{VV} < 3.0$

First from CMS

1D Likelihood scan

- ttH process → gives better constraints on κ_t and λ_{HHH}
- Selection of events for ttH process are mutually exclusive to HH categories



→ Inclusion of ttH makes positive κ_λ preferable
rules out negative κ_λ at 95% CL

LHCP2021

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Paris (France), Sorbonne Université (IN2P3/CNRS/IRFU/CEA)

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