Introduction

- The main backgrounds include non-resonant \( \gamma \gamma \) events and single Higgs from \( H \to \gamma \gamma \) (ggF, VBF, \( t\bar{t}H \)).
- In each mass region a boosted decision tree (BDT) is trained to separate the \( HH \) signal from the backgrounds.
- The training uses kinematic variables related to the photons and jets such as \( m_{bb} \) and \( \rho_{\gamma}\gamma/m_{\gamma\gamma} \).
- A total of 4 signal sensitive categories are created using the BDT outputs.

Analysis Results

- The \( HH \) signal is obtained from a simultaneous fit to the diphoton mass spectrum \( m_{\gamma\gamma} \) across all categories.
- No significant excess is observed and upper limits are set at 95% CL.

Analysis Strategy

- Events with two photons and two b-jets are selected.
- Events are divided into a high mass (targeting SM-like signals) and low mass region (targeting non SM-like signals) using the modified 4-body mass \( m_{bb\gamma\gamma} = m_{bb\gamma\gamma} - (m_{bb} - 125 \text{ GeV}) - (m_{\gamma\gamma} - 125 \text{ GeV}) \).

Figure 1: Leading order diagrams for \( HH \) ggF production.

Figure 2: Leading order diagrams for \( HH \) VBF production.

Figure 3: The \( m_{bb\gamma\gamma} \) distribution for various \( HH \) signals (left) and the expected \( m_{\gamma\gamma} \) composition for signals and backgrounds (right).

Figure 4: The BDT distribution of the \( HH \) ggF signal in the high mass region.

Figure 5: The fitted diphoton mass spectrum from the most sensitive category in the high mass region (left) and the \( HH \) cross-section limits as a function of \( \kappa_\lambda \) (right).

Figure 6: A candidate \( HH \to bb\gamma\gamma \) event, showing two b-jets (red cones) with an invariant mass of 113 GeV and two photons (cyan towers) with an invariant mass of 123 GeV.