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Search for resonant double Higgs production in the bb$\tau\tau$ final state at the CMS experiment.

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Abstract

This thesis presents a search for resonant Higgs boson pairs (HH) production via gluon-gluon fusion (GGF) mechanisms, predicted by some Beyond the Standard Model (BSM) scenarios to be observable with the current dataset collected by the LHC experiments. The search focuses on the $HH \to b\bar{b}\tau^+\tau^-$ final state where one Higgs decays in $b\bar{b}$ quark pair and the other decays in the $\tau^+\tau^-$ lepton pair.
This final state has a sizeable branching fraction ($BR \to 7.3\%$) and a quite efficient signature of the H decaying into a $\tau^+\tau^-$ pair. However, this channel presents significant challenges due to neutrinos in τ decays and background discrimination. Advanced techniques are employed for τ reconstruction and identification, along with sophisticated modeling of the relevant backgrounds.
The $\tau^+\tau^-$ pair is studied through three decay channels: $\tau_h\tau_h$ (fully hadronic) and $\tau_h\tau_\ell$, where τ_h represents a tau lepton decaying into hadrons plus a ν_τ , and τ_ℓ corresponds to the leptonic decay of the tau into either an electron ($\ell = e$) or a muon ($\ell = \mu$).

The analysis utilizes data collected by the CMS experiment during the LHC Run II period (2016−2018), corresponding to proton-proton collisions at a center-of-mass energy of $\sqrt{s}$ = 13 TeV and an integrated luminosity of 137.1 fb^{-1}. As part of the CMS internal review process, the analysis remains blinded, meaning that the observed data are not used in the statistical analysis to prevent bias. The 95% Confidence Level upper limit on the HH production cross section are set as a function of resonance spin and mass, interpreted within the BSM Warped Extra Dimensions (WED) model for a resonance with a mass in the range from 250 to 3000 GeV for spin 0 and spin 2 hypotheses.