UNIVERSITÀ DI SIENA 1240

Department of
Physical Sciences, Earth and Environment

Ph.D. in Experimental Physics
XXXVI Cycle

Coordinator: Prof. Riccardo Paoletti

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

Disciplinary Scientific Sector: FIS/01

PhD Student
Valeria D'Amante
University of Siena
Via Roma 56, 53100 Siena (Italy)

Signature:

Supervisor
Prof. Maria Agnese Ciocci
University of Siena
Via Roma 56, 53100 Siena (Italy)

Signature:

Academic Year 2023-2024

Abstract

This thesis presents a search for resonant Higgs boson pair production via gluon-gluon fusion (HH) and targeting Beyond the Standard Model (BSM) scenarios such as the Warped Extra Dimensions (WED) model which predict resonances, including CP-even scalar particles, that enhance the HH production cross section at specific invariant masses.
The search focuses on the $HH \to b\bar{b}\tau^+\tau^-$ final state, which balances signal purity with a branching ratio of 7.3%, but poses challenges due to neutrinos in τ decays and background discrimination, requiring advanced reconstruction techniques. The $\tau^+\tau^-$ system is studied through three decay channels: $\tau_h\tau_h$ (fully hadronic) and $\tau_h\tau_\ell$ (semileptonic, with $\ell = e/\mu$).

To perform this search, proton-proton collision data at $\sqrt{s} = 13$ TeV collected by the CMS detector during 2016–2018 have been used, for a total integrated luminosity of 137.1 fb^{-1}. A blind analysis approach is employed to avoid biases during the statistical analysis, excluding observed data, and only expected results are reported. Upper limits on the HH production cross section are set as a function of resonance mass and interpreted within the WED framework, offering new insights into potential BSM physics.