

Thesis outline: Search for exotic Higgs decays to light neutral scalar particles at CMS

Stephanie Kwan

March 15, 2024

1 Outline

1. Abstract
2. Preliminaries
 - (a) Acknowledgments
 - (b) Contents
 - (c) List of figures
 - (d) List of tables
3. Introduction
 - (a) The Standard Model
 - (b) Gauge groups
 - (c) The Higgs mechanism
 - (d) Two Higgs Doublet Models (2HDMs)
 - (e) Two Real Singlet Models (TRSM)
4. The Large Hadron Collider and the CMS Experiment
 - (a) CERN and the Large Hadron Collider
 - (b) The CMS Detector
 - (c) Sub-detectors
 - (d) The Level-1 Trigger and High Level Trigger
 - (e) Particle-Flow reconstruction
 - (f) Data processing
 - (g) Phase-2 Upgrade of CMS
 - (h) e/γ stand-alone barrel reconstruction in Phase 2
5. Datasets and Monte Carlo samples
6. Object reconstruction and corrections applied
 - (a) Lepton and jet identification and object selection
 - i. τ leptons
 - ii. Muons
 - iii. Electrons
 - iv. B-flavour jets
 - (b) Reconstruction of di-tau mass (SVFit, FastMTT)
 - (c) Scale factors and corrections applied to simulation

7. Event selection
 - (a) $e\mu$ channel
 - (b) $e\tau_h$ channel
 - (c) $\mu\tau_h$ channel
8. Background estimation
 - (a) Z+jets
 - (b) W+jets
 - (c) $t\bar{t}$ + jets
 - (d) Diboson, single top, and SM Higgs
 - (e) QCD multi-jet for $e\mu$ channel
 - (f) Jet $\rightarrow \tau_h$ fake method for $e\tau_h$ and $\mu\tau_h$ channels
9. Systematic uncertainties
10. Event categorization and signal extraction
 - (a) Categorization by b-tag multiplicity
 - (b) Categorization by DNN score
 - (c) Methodology for signal extraction
11. Results
12. $h \rightarrow a_1 a_2$ studies
13. Conclusions and outlook
14. References