T 36: Higgs Boson: Extended Models 1

Time: Tuesday 16:15–18:30 Location: T-H21

T 36.1 Tue 16:15 T-H21

Search for heavy Higgs bosons decaying to top quark pairs using the CMS experiment — Afiq Anuar, Alexander Grohsjean, •Jonas Rübenach, Dominic Stafford, and Christian Schwanenberger — DESY, Hamburg, Germany

The discovery of the Higgs boson at the Large Hadron Collider in 2012 marked a major breakthrough for particle physics, as it permits the verification of the Higgs mechanism, a central building block of the Standard Model. However, the Standard Model still lacks explanation for many phenomena we observe throughout the universe, including dark matter. For a great number of proposed extensions, such as the minimal supersymmetric standard model, a key ingredient is the existence of additional Higgs bosons. Using data collected by CMS at the LHC at $\sqrt{s} = 13$ TeV, corresponding to a luminosity of 138 fb^{-1}, a search is performed for scalar and pseudoscalar, electrically neutral bosons decaying predominantly to top quark pairs, which are assumed to further decay dileptonically. The challenges connected to this particular search, such as interference with the standard model background and unknown quantities resulting from neutrino momenta, are tackled by a full reconstruction of the top quark system and the utilization of multi-dimensional distributions arising from mass and spin information.

T 36.2 Tue 16:30 T-H21

Exotic Higgs Decays: ATLAS Search for Higgs Decays to Two Light Scalars — •Judith Höfer, Claudia Seitz, Rickard Strom, and Beate Heinemann — DESY, Hamburg, Germany

Extensions of the SM Higgs sector featuring one or several singlet scalar fields are realised in many BMS models. While several searches have been performed targeting decays of the SM Higgs boson to two light spin-zero particles of the same mass, the decay to two new scalars of different mass is largely unexplored. The successive decays of these particles can give rise to spectacular high-multiplicity collider signatures, including so-called cascade decays, where the heavier of the scalars decays into the lighter one. The talk discusses an analysis searching for scalar decays to multi-b final states with the ATLAS experiment at the Large Hadron Collider, CERN. The analysis focuses on the ZH production mode and the channel where the scalars decay to b-quarks, resulting in a challenging low-pT jet final state. These signatures motivate the use of many novel reconstruction techniques, such as the reconstruction of soft secondary vertices, a newly developed low-pT X->bb tagger, and an event hypothesis neural network to accurately identify the Higgs decay to the light scalars among the reconstructed objects.

T 36.3 Tue 16:45 T-H21

Search for DiHiggs production H → hh$_S$ in an extended NMSSM Higgs sector with CMS — •Martin Marz, Felix Heyen, Ulrich Husemann, Nikita Shadskiy, Michael Wassmer, and Roger Wolf — Institute of Experimental Particle Physics (ETP), Karlsruhe Institute of Technology (KIT)

The search for new physics is essential to validate or exclude theoretical models. For this purpose, models including additional non-standard-model-like Higgs bosons are of great interest. The Next-to-Minimal Supersymmetric Standard Model (NMSSM) for example predicts such additional Higgs bosons. Especially the decay of a heavy Higgs boson H into two lighter Higgs bosons (h_S, h), allows for a rich experimental program. Here h is the observed Higgs boson with properties as expected by the SM.

The analysis presented in this talk is intended to use a general re-reconstruction of the LHC run 2 dataset from 2018 to profit from the best understanding of physics objects measured and reconstructed with the CMS detector in the search of new physics. The decay channel h → bb, $h_S \to \tau\tau$ and the subsequent decay of the tau pair into a muon and hadrons is studied to add to a recently published analysis (JHEP 11 (2021) 057) by the CMS collaboration.

T 36.4 Tue 17:00 T-H21

Verwendung parametrischer neuronaler Netzwerke bei der Suche nach neuer Physik im Rahmen von NMSSM inspirierten Modellen — •Ralf Schmieder, Markus Klute, Günter Quast, Roger Wolf, Sebastian Brommer, Maximilian Burkart, Felix Heyen und Tim Voigtländer — KIT, Karlsruhe, Deutschland

Ein parametrisches neuronales Netzwerk (pNN) ist äquivalent zu einer Folge einzelner, verwandter NNs, von denen jedes eine eigene Aufgabe erfüllt. Diese Äquivalenz wird erreicht, indem der Raum der Eingangsparameter des pNNs, im Vergleich zu den einzelnen NNs, um zusätzliche Modellparameter erweitert wird. Das pNN erfüllt dann, abhängig von diesen Modellparametern, die Aufgaben der einzelnen NNs. Ein typisches Beispiel für den Einsatz eines pNN in der Teilchenphysik ist die Suche nach einem neuartigen Teilchen mit unbekannter Masse. In diesem Fall wird der aus physikalischen Observablen bestehende Raum der Eingangsparameter der einzelnen NNs um den Modellparameter der Masse des neuen Teilchens für die jeweils zu testende Signalhypothese erweitert.

Dieser Vortrag behandelt Studien zu pNNs im Kontext einer durch das NMSSM inspirierten Analyse der Daten des CMS Experiments. Gesucht wird nach dem Zerfall eines schweren Higgs-Bosons H in zwei leichtere Higgs-Bosonen h und h_S im Endzustand mit zwei τ-Leptonen und zwei b-Quarks, $H \to h(\tau\tau)h_S(bb)$, unter der Annahme von $m(h) = 125\,\text{GeV}$. Dieses Problem besitzt zwei unbekannte Massen $m(H)$ und $m(h_S)$, die von der zu testenden Signalhypothese abhängen und beide als Modellparameter in das pNN Training eingehen sollen.

T 36.5 Tue 17:15 T-H21

Search for NMSSM inspired di-Higgs events in bb+$\tau\tau$ final states — •Felix Heyen, Ralf Schmieder, Sebastian Brommer, Günter Quast, Roger Wolf, Nikita Shadskiy, Martin Marz, and Maximilian Burkhart — KIT, Karlsruhe

In the next-to-minimal supersymmetric extension of the Standard Model (NMSSM), modifications to the Standard Model Electroweak sector lead to an extended Higgs sector with a total of seven Higgs bosons. The decay of a heavy scalar Higgs boson to a light scalar Higgs boson and a Higgs boson with the properties of the discovered Higgs boson is a promising target of this extension. This talk discusses the physics motivations of the NMSSM and introduces the search for such a decay in $\tau\tau$ + bb final states. Of the possible tau lepton final states that can be considered, this search focusses on $\tau_h\tau_h$ final state. A simulation of the 2018 CMS data taking period is considered.

T 36.6 Tue 17:30 T-H21

Search for additional MSSM/2HDM H→bb with Run 2 CMS data — •Daina Leyva Pernia — DESY, Hamburg, Germany

Some Beyond Standard Model (BSM) theories, like the Minimal Supersymmetric extension of the Standard Model (MSSM) or the Two-Higgs Doublet Model (2HDM), predict the existence of additional Higgs bosons with an enhanced coupling to bottom quarks. This talk focuses on the search for new neutral Higgs bosons decaying into b-quarks and produced in association with at least one b-quark. The analyzed data were collected by the CMS experiment at a centre-of-mass energy of 13 TeV, with the latest data reprocessing. First limits on the MSSM H→bb process using these data are shown.

T 36.7 Tue 17:45 T-H21

A 96 GeV Higgs Boson in the 2HDM plus Singlet — •Cheng Li[1], Steven Paasch[1], Gudrid Moortgat-pick[1,2], Sven Heinemeyer[3], and Florian Lika[2] — [1]DESY, Notkestraße 85, Hamburg, Germany — [2]II. Institut für Theoretische Physik, Universität Hamburg,
Luruper Chaussee 149, Hamburg, Germany — [3]Instituto de Física Teórica (UAM/CSIC), Universidad Autónoma de Madrid, Cantoblanco, Madrid, Spain

We discuss a $\sim 3\,\sigma$ signal (local) in the light Higgs-boson search in the diphoton decay mode at ~ 96 GeV as reported by CMS, together with a $\sim 2\,\sigma$ excess (local) in the $b\bar{b}$ final state at LEP in the same mass range. We interpret this possible signal as a Higgs boson in the 2 Higgs Doublet Model type II with an additional Higgs singlet, which can be either complex (2HDMS) or real (N2HDM). We find that the lightest $\mathcal{CP}$-even Higgs boson of the two models can equally yield a perfect fit to both excesses simultaneously, while the second lightest state is in full agreement with the Higgs-boson measurements at 125 GeV, and the full Higgs-boson sector is in agreement with all Higgs exclusion bounds theoretical and experimental constraints. We derive bounds on the 2HDMS and N2HDM Higgs sectors from a fit to both

excesses and describe how this signal can be further analyzed at future e^+e^- colliders. We analyze in detail the anticipated precision of the coupling measurements of the 96 GeV Higgs boson at the ILC. We find that these Higgs-boson measurements at the LHC and the ILC cannot distinguish between the two Higgs-sector realizations.

T 36.8 Tue 18:00 T-H21

Dark Matter Phenomenology in Two Higgs Doublet Model with a Complex Singlet — Gudrid Moortgat-Pick, Juhi Dutta, and •Julia Ziegler — II. Institut für Theoretische Physik Universität Hamburg, Luruper Chaussee 149, 22761 Hamburg, Germany

Although the Standard Model is very successful, there are still open problems which it cannot explain. (e.g. dark matter, baryon asymmetry etc.) This has led to various Beyond Standard Model theories, of which Two Higgs Doublet models are very popular, as they are one of the simplest extensions and lead to a rich phenomenology. We consider a Two Higgs Doublet model extended by a complex singlet scalar, where both, the doublets, as well as the singlet obtain a vacuum expectation value (vev). The singlet serves as a dark matter candidate. This model can solve the above mentioned problems and can also provide gravitational wave signals under specific circumstances, respectively. Furthermore one could obtain additional mixing of the dark matter and Higgs sector through the singlet vev. In this work we examine the influence of the parameters of the singlet potential on the dark matter relic density and nuclear scattering cross sections. The results are then compared with constraints from experiments.

T 36.9 Tue 18:15 T-H21

Impact of the different discrete symmetries in the 2HDM and N2HDM on Domain Wall formation and its phenomenological implications — •Luis Hellmich[1] and Gudrid Moortgat-Pick[1,2] — [1]Universität Hamburg, Hamburg, Deutschland — [2]DESY, Hamburg

Domain wall formation is a consequence of spontaneously broken discrete symmetries. Stable domain walls are cosmological bad news as they are expected to dominate the energy density of the universe. One way to overcome this domain wall problem are energetically biased vacua, which can render domain walls unstable.

In the 2HDM and N2HDM a discrete $\mathbb{Z}_2$ symmetry is usually present in order to avoid FCNCs, which is softly broken and hence can produce collapsing domain walls. We find that in the Type I 2HDM and N2HDM there is an additional inherent and not explicitly broken $\mathbb{Z}_2$ symmetry. Furthermore the N2HDM also exhibits the well-known only spontaneously broken $\mathbb{Z}_2'$ symmetry. We want to discuss the impact of those different discrete symmetries on domain wall formation. In particular we want to show how stable domain walls for the unbroken discrete symmetries may be suppressed and analyze the phenomenological consequences when applying the resulting constraints on the 2HDM and N2HDM.