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Global fit of 2HDM with future collider results

Ankit Beniwal[a], Filip Rajec[b], Markus Tobias Prim.[c], Pat Scott[d,e], Wei Su[b], Martin White[b], Anthony G. Williams[b], and Alex Woodcock[b]

[a]Centre for Cosmology, Particle Physics and Phenomenology (CP3), Université catholique de Louvain, B-1348 Louvain-la-Neuve, Belgium
[b]ARC Centre of Excellence for Particle Physics at the Terascale, Department of Physics, University of Adelaide, South Australia 5005, Australia
[c]Physikalisches Institut der Rheinischen Friedrich-Wilhelms-Universität Bonn, 53115 Bonn, Germany
[d]School of Mathematics and Physics, The University of Queensland, St. Lucia, Brisbane, QLD 4072, Australia
[e]Department of Physics, Imperial College London, Blackett Laboratory, Prince Consort Road, London SW7 2AZ, UK

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Thematic Areas:

- (EF01) EW Physics: Higgs Boson properties and couplings
- (EF02) EW Physics: Higgs Boson as a portal to new physics
- (EF04) EW Precision Physics and constraining new physics
- (EF08) BSM: Model specific explorations
- (TF07) Collider phenomenology

Abstract

In this LOI, we propose the study of future SM-like Higgs and Z measurements effects on the Type-I and Type-II two Higgs doublet models (2HDM). The work will be based on the coming results of a global fit of 2HDMs with the tool `GAMBIT`, utilising various current constraints including theoretical constraints (unitarity, perturbativity and vacuum stability), Higgs searches at colliders, electroweak physics and flavour constraints. We will investigate the ability of future Higgs factories, such as CEPC, ILC and FCC-ee, to explore the 2HDM parameter space.

The discovery of a Standard Model (SM)-like Higgs boson at the Large Hadron Collider (LHC) set a milestone for high energy physics, confirming the self consistency of the SM. At the same time there are also various unsolved mysteries, such as the source of dark matter, the baryon asymmetry of the universe, and the muon g-2 anomaly. Models with extended Higgs sectors provide promising solutions for these signals.

*Email address: ankit.beniwal@uclouvain.be, filip.rajec@adelaide.edu.au, markus.prim@cern.ch, pat.scott@uq.edu.au, wei.su@adelaide.edu.au, martin.white@adelaide.edu.au, anthony.williams@adelaide.edu.au, alexander.woodcock@student.adelaide.edu.au

As one of the simplest frameworks, the Two Higgs Doublet Model (2HDM) is embedded in various models with extended Higgs sectors, such as the Minimal Supersymmetric Standard Model, gauge extensions (such as the Left-Right symmetric model), and flavour models. After electroweak symmetry breaking (EWSB), the general CP-conserving 2HDM can generate five physical eigenstates: the observed 125 GeV CP-even neutral scalar h, an additional CP-even neutral scalar H, one CP-odd Higgs boson A, and a pair of charged Higgs boson $H^{\pm}$ [1]. Thus, exploring the properties of 2HDMs with various experimental constraints can help enlighten the new physics potential of a broad class of BSM scenarios.

At present, we have carried out global fits of the Z_2-Yukawa symmetric 2HDM [1], specifically the Type-I, Type-II, lepton specific and flipped models. This analysis is carried out using the open-source tool `GAMBIT` [2] (Global and Modular beyond-Standard Model Inference Tool). `GAMBIT` is compatible with both the Bayesian and frequentist statistical frameworks, and we here focus on frequentist results obtained with the `Diver` [3] implementation of the differential evolution algorithm. We investigated the effect of theoretical constraints (unitarity, perturbativity and vacuum stability), Higgs searches at colliders, electroweak physics and flavour constraints individually, as well as displaying the final results including all constraints. We found that the typically allowed region is $t_\beta \in (1, 50)$, $m_A \in (300, 1000)$ GeV, where the mass upper limit comes from the loop corrected SM-like Higgs mass constraints.

Nowadays there have been many Higgs factory proposals, including the CEPC in China [4, 5], the FCC-ee at CERN [6–11] and the ILC in Japan [12–15], which can reach sub-percentage precision on the Higgs properties. In addition, it is foreseen to run these colliders at the Z-pole. These machines will provide improved measurements of SM parameters, demonstrating an impressive potential for future precision measurements of SM Higgs observables [16, 17].

Based on these analyses, we propose a global fit study of the 2HDM with hypothetical data from Higgs and Z pole precision measurements at future Higgs factories.

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