Search for Super Symmetry in the Higgs sector

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The first years of the LHC running have lead the discovery of the Higgs boson with properties very close to those predicted for a Higgs boson of the Standard Model (SM). At the same time numerous searches for physics beyond the Standard Model (BSM) have been performed, particular for Super Symmetry (SUSY), the most popular and best-motivated possible extension of the SM. No supersymmetric particle has been discovered so far and the possible mass scale for such particles seems now to be close to one TeV, possibly accessible in the present Run of the LHC with a higher centre of mass energy of 13 TeV.

Besides the existence of new particles, Super Symmetry predicts a significant modification of the Higgs sector: The simplest realization, the Minimal Supersymmetric Standard Model (MSSM), adds one more neutral CP-even Higgs boson, one CP-odd Higgs boson and a pair of charged Higgs bosons to the Standard Model Higgs. In other extensions, for example the Next to Minimal Supersymmetric Standard Model (NMSSM), there will be more neutral bosons, three neutral scalars and two neutral pseudo-scalars. Depending on their respective masses it will be possible to study Higgs-Higgs interactions by decays of one Higgs boson to another one, giving new and often spectacular signatures (see for example arXiv:1408.1120v1).

The Run of the LHC, which has started this year with high luminosity at a centre of mass energy of 13 TeV will allow probing these extensions of the Higgs sector with different search channels and analysis strategies. This will be the central subject of the thesis proposed here. The PhD thesis, which could be preceded by a Master thesis in Spring 2016, will be carried out at the IPHC, Strasbourg within the group working on the CMS experiment at the LHC.

The thesis will start in October 2016 with an analysis based on a phenomenological feasibility study (Monte-Carlo simulation level, work in progress) having identified one or two of the most promising search channels for such a non-standard Higgs boson and having evaluated its discovery potential for the new LHC data at 13 TeV. The experimental signatures and challenges in the analysis will be tau-lepton and b-jet identification or low momentum photons: we will look at final states like *“bb* + □□□+ □□*”*. Such signatures are also typical for double Higgs production of the Standard Model. The CMS group in Strasbourg is the leading team in CMS working on b-jet recognition and has also important knowledge on tau-identification. The data analysis and the corresponding programmes will be developed in the context of the CMS collaboration, especially within the Higgs-working groups. Collaborating with other CMS groups (Lyon, Paris and others) will also be necessary. Close contacts with theoretical physicists in France (GDR Terascale network) and in Germany (KIT), specialists of the NMSSM, are foreseen in order to work towards a discovery of Super Symmetry in the Higgs sector. In the absence of a discovery we will be able to place strong limits on parts of the SUSY parameter space within the framework of the NMSSM or for SUSY in general.

The PhD candidate should have an excellent academic record and knowledge in programming (C++ and Root). Further she/he should have the necessary communication skills to work across the international CMS collaboration.