Searches for BSM Higgs at CMS

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These proceedings report the results on the Higgs Searches beyond the standard model at the CMS experiment with data collected during the 2011 LHC run at 7 TeV, corresponding to an integrated luminosity of about 5 fb^{-1}. Results for several models are shown from analyses performed by the CMS collaboration. No significant deviation from the standard model is found and limits on the Higgs mass are set for each physics scenario.

1 Introduction

The standard model (SM) of Particle Physics describes very precisely the experimental measurements up to now but one of its key ingredient has not yet been observed: the Higgs boson, which is at the source of the electro-weak symmetry breaking and provides a mechanism to assign mass to particles. It is clear, however, that the SM theory breaks at larger scales and some major open points are the unification of couplings, hierarchy problem, dark matter issue and neutrino masses. Theories have been proposed that attempt to answer some of these open questions such as supersymmetry (SUSY) or other beyond standard model (BSM) scenarios and are currently under experimental test. The CMS experiment, a multi-purpose detector [1] operating at the CERN LHC pp collider, has been designed to investigate a wide range of physical phenomena. In these proceedings, the latest BSM Higgs searches at the CMS experiment will be briefly described. These results are achieved by the CMS collaboration with data collected in 2011 corresponding luminosity of about 5 fb^{-1}.

2 Minimal supersymmetric standard model Higgs

In the MSSM, the standard scalar Higgs boson is substituted by three neutral ϕ = (h,H,A) and two charged ($H^{\pm}$) Higgs particles and all decays to *down-type* fermions are enhanced by a factor of *tan* β. For relatively high *tan* β the BR ($\phi \to \tau^+\tau^-$) is about 10% which is much lower than the corresponding branching ratio of the b-decay mode. Neutral MSSM Higgs bosons are searched in the di-tau final state which is preferred for its clear signature in the two leptons final states (electrons or muons) and in the lepton plus an hadronic decaying τ final state. The dilepton channel was searched in dimuons and in electron-muon final states. The hadronic τ is reconstructed in 1 and 3 prongs ($+N\pi^0$). To extract the di-tau mass a kinematic fit is applied to the measured components, including the missing energy, with an improvement of about 20% on the measured mass [2]. In Figure 1(left) is shown the exclusion plot for the neutral MSSM Higgs mass versus tan β. For *tan* $\beta = 20$ *H*iggs masses up to 300 GeV/$c^2$are excluded.

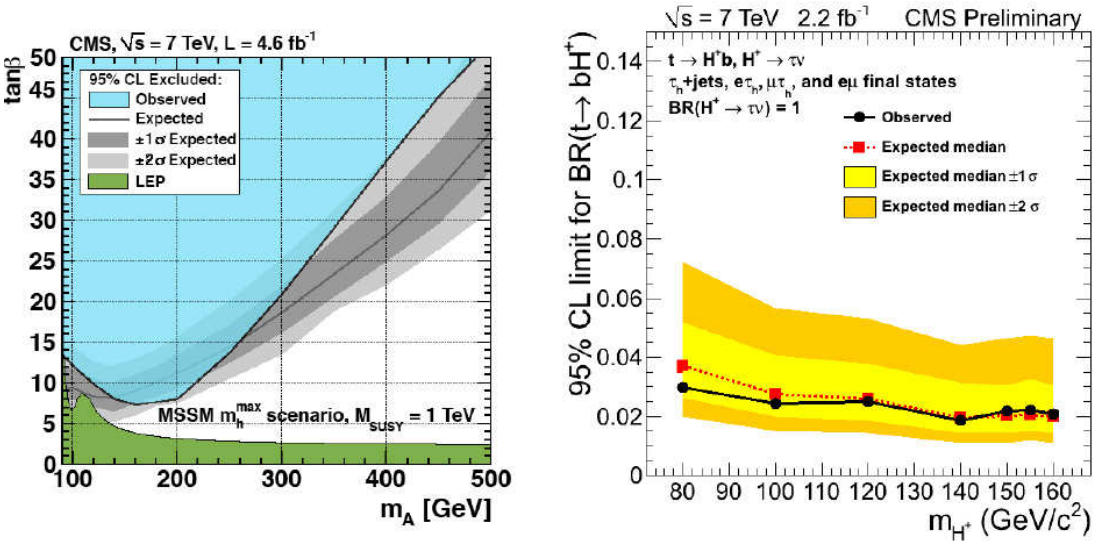

Figure 1: Left: Region in the parameter space of tan β versus m_A excluded at 95% CL in the context of the MSSM scenario. 95% CL upper limit and the expected one- and two-standard-deviation ranges are shown together with the observed excluded region. Right: Upper limit on BR($t \to bH^+$) assuming BR($H^+ \to \tau^+\nu$)=1 as a function of m_{H^+}). The yellow bands show the one and two sigma bands around the expected limit.

The charged MSSM Higgs bosons are searched in the top decays $t \to bH^\pm$ with the tau final states $H^+ \to \tau^+\nu$. The $t\bar{t}$ production yields with tau final states are modified by Higgs diagrams if the Higgs mass is lower than the top mass. The Higgs particle is searched in isolated τ decays plus b-jets and possibly an isolated lepton in the final state, depending on the second top decay chain in the $t\bar{t}$ events. Results from this analysis [3] on BR($t \to bH^+$) are shown in Figure 1(right). Values of BR($t \to bH^+$) $> 4\%$ are excluded for all the possible Higgs mass values.

3 Light pseudoscalar Higgs boson

The presence of a light pseudoscalar CP-odd Higgs a is predicted within the next to minimal supersymmetric extension to the standard model. This search [4] has been performed in the sidebands of the $\Upsilon \to \mu^+\mu^-$ dimuon decays, namely $5.5 < M(\mu\mu) < 9$ GeV/c^2 and $11.5 < M(\mu\mu) < 14$ GeV/c^2. A special high level trigger conceived for charmonium states studies was set up and this analysis was performed with a data sample corresponding to a luminosity of 1.3 fb^{-1}. Results are shown in Figure 2 with no excess found in the dimuon spectrum. An upper limit on the cross-section $\sigma(pp \to a \to \mu^+\mu^-)$ below 5 pb is set for all the masses in the two search intervals.

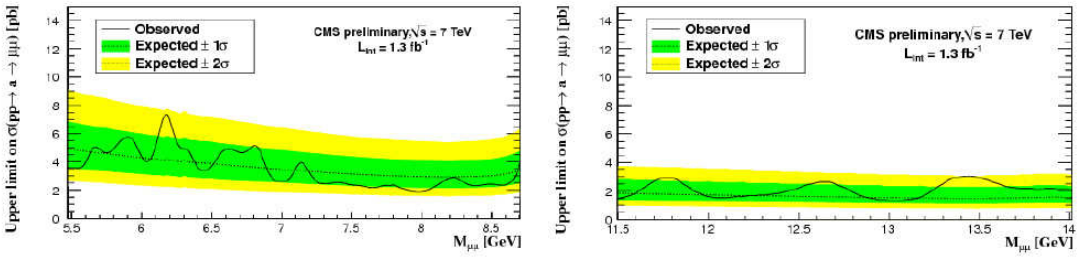

Figure 2: Limits on the cross-section $\sigma(pp \to a \to \mu^+\mu^-)$ for the two mass intervals in the Υ sidebands.

4 Doubly charged H^{++}

These exotic Higgs bosons are predicted within the *type II* see-saw model and are related to the presence of a light neutrino mass. H^{++} decay to two same charged leptons and obviously do not have any physical background in the SM. They are produced in pairs or together with a single charged Higgs through the processes: $Z/\gamma \to H^{++}H^{--}$ and $W^+ \to H^{++}H^-$ (charge conjugates included), giving a final states with four or three leptons, same charge resonant. No excess is observed in the CMS data. In Figure 3(left) are shown the mass limits for the different leptonic final states and four benchmark points of the see-saw mechanism [5].

5 Fermiophobic Higgs boson decays

In the Fermiophobic model the gluon-gluon process of Higgs production is forbidden and the production cross-section is suppressed by an order of magnitude with the Vector Boson Fusion (VBF) and the Higgs-strahlung (VH) that become the two most important contributions to Higgs production. On the other hand, the diphoton decay $H \to \gamma\gamma$ is enhanced by another order of magnitude. This analysis is based on the selection of two high p_T photons and three tag classes with electron, muon or dijets in the final states [6] corresponding to different decays in the associate production. The results are presented in Figure 3(right) and show a small excess at 126 GeV/c^2 which is diluted when the diphoton channel is combined [7] with $H \to WW, ZZ$. Two intervals of Higgs mass are excluded at 95% of C.L.: $110 < M_H < 124$ GeV/c^2 and $128 < M_H < 136$ GeV/c^2.

6 Other results

Other result to be mentioned here are the standard model SM4 extensions searches obtained including a fourth quark generation [7] that significantly increase the Higgs bosons production rate. The SM4 model is excluded at 95% CL from 120 up to 600 GeV/c^2 of Higgs masses.

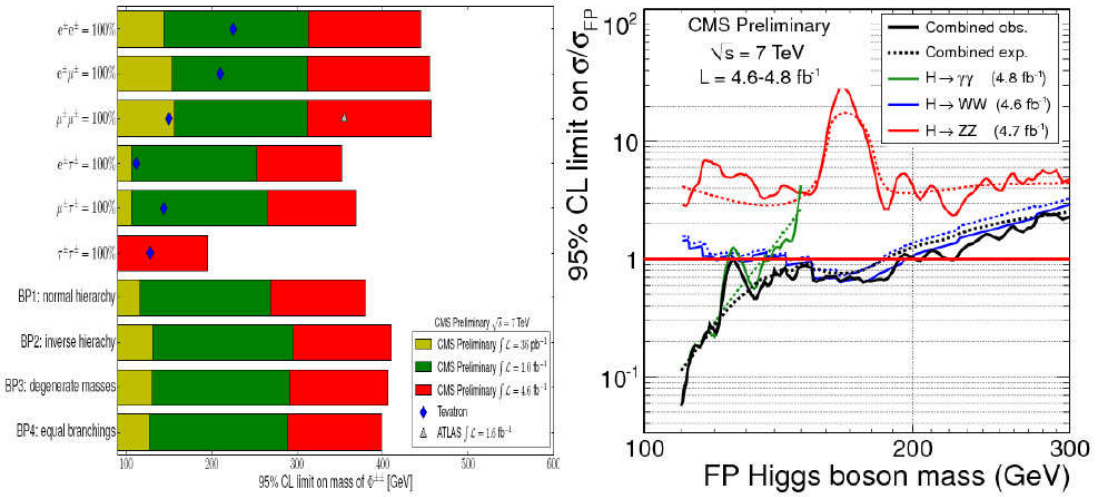

Figure 3: Left: Limits on the mass of the doubly charged Higgs bosons for different final states. Right: The 95% CL upper limits on the signal strength parameter $\mu = \sigma/\sigma_{FP}$ for the fermiophobic Higgs boson hypothesis as function of the Higgs boson mass with the contribution for the three explored Higgs boson decay modes in the full mass range.

7 Conclusions

A broad program of BSM Higgs bosons searches with CMS has been presented. Model independent inclusive searches together with well defined new physics scenarios have been probed during 2011 with a luminosity of about 5 fb^{-1}. A large fraction of the MSSM Higgs parameters are constrained by the $H \to \tau^+\tau^-$ analysis. A small excess on the $H \to \gamma\gamma$ is registered, compatible with a statistical fluctuation. No evidence for new BSM Higgs bosons is observed. The 2012 run, with about 15 fb^{-1} of data collected, will help to improve these searches.

References

[1] S. Chatrchyan *et al.* [CMS Collaboration], JINST **3** (2008) S08004.

[2] S. Chatrchyan *et al.* [CMS Collaboration], arXiv:1202.4083 [hep-ex], submitted to PLB.

[3] S. Chatrchyan *et al.* [CMS Collaboration], "Search for the light charged Higgs boson in top quark decays in pp collisions at sqrts = 7 TeV," CMS-PAS-HIG-11-019

[4] S. Chatrchyan *et al.* [CMS Collaboration], "Search of a light pseudoscalar Higgs boson in the dimuon channel," CMS-PAS-HIG-12-004

[5] S. Chatrchyan *et al.* [CMS Collaboration], "Search for Doubly Charged Higgs," CMS-PAS-HIG-12-005

[6] S. Chatrchyan *et al.* [CMS Collaboration], "Search for the fermiophobic model Higgs boson decaying into two photons," CMS-PAS-HIG-12-002

[7] S. Chatrchyan *et al.* [CMS Collaboration], "Combination of SM, SM4, FP Higgs boson searches," CMS-PASHIG-12-008