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A 96 GeV Higgs Boson in the 2HDM plus Singlet

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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 2Higgs Doublet Model type II with an additional Higgs singlet, which can be either complex (2HDMS) or real (N2HDM), where the 2HDMS so far has never been analyzed as an explanation of these excesses. An emphasis of our work are the differences between and the possible distinction of the two models in this context.

We find that the lightest 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 from LEP, the Tevatron and the LHC as well as other 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, such as the ILC. 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.

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