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Possible indications for new Higgs bosons in the reach of the LHC: N2HDM and NMSSM interpretations

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In several searches for additional Higgs bosons at the LHC, in particular the CMS search in the $pp \rightarrow \phi \rightarrow t\bar{t}$ channel and the ATLAS search in the $pp \rightarrow \phi \rightarrow \tau^+\tau^-$ channel, a local excess at the level of 3σ or above has been observed at a mass scale of $m_\phi \approx 400\text{GeV}$.

We investigate to what extent a possible signal in those channels could be accommodated in the Next-to-Two-Higgs-Doublet Model (N2HDM) or the Next-to Minimal Supersymmetric Standard Model (NMSSM).

In a second step we furthermore analyse whether such a model could be compatible with both a signal at $\approx 400\text{GeV}$ and at $\approx 96\text{GeV}$, where the latter possibility is motivated by observed excesses in searches for the $b\bar{b}$ final state at LEP and the di-photon final state at CMS.

The analysis for the N2HDM reveals that the observed excesses at $\approx 400\text{GeV}$ in the

$pp \rightarrow \phi \rightarrow t\bar{t}$ and

$pp \rightarrow \phi \rightarrow \tau^+\tau^-$ channels point

towards different regions of the parameter space, while one such excess and an additional Higgs boson at $\approx 96\text{GeV}$ could simultaneously be accommodated. In the context of the NMSSM

an experimental confirmation of a signal in the $t\bar{t}$ final state would favour

the alignment-without-decoupling limit of the model, where the Higgs boson at $\approx 125\text{GeV}$ could be essentially indistinguishable from the Higgs boson of the SM.

In contrast,

a signal in the $\tau^+\tau^-$ channel would be correlated with significant deviations of the properties of the Higgs boson at $\approx 125\text{GeV}$

from the ones of a SM Higgs boson that could be detected with high-precision coupling measurements.

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