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Resonances all over the place?

Given the very large number of searches for resonances at the LHC, it comes as no surprise, statistically speaking, that excesses are occasionally observed in the data, that might or might not stand the test of time.
However, when these excesses are found to occur at the same invariant mass in different search channels, a theoretical interpretation becomes instructive. Indications for a 95GeV electrically neutral scalar produced in association with a Z boson and decaying to bbar, have been around since the LEP. Further indications around the same mass came later on from CMS both in diphoton and tautau decays of a singly produced object, triggering various interpretations in terms of singlet/doublet extensions including SUSY.
Less popular, though, are the recent indications from CMS and ATLAS for a singly produced 650GeV electrically neutral scalar decaying to WW, to ZZ, to the SM Higgs and the 95GeV scalar, as well as to new lighter states in cascade or in association with a Z boson. Even more so, combining the corresponding p-values of these excesses gives a global significance of 4 sigma, higher than that for the 95GeV.
We argue that a theoretical framework accounting for the SM Higgs and these two hypothetical scalars is not straightforward: It disfavours singlet/doublet-only Higgs extensions, necessitates the existence of doubly charged scalar states while still disfavouring canonical triplet Higgs extensions like the Georgi-Mchacek model.
A viable BSM extension is then presented as well as the ensuing predictions for other scalar states.

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Auteurs principaux: Prof. KUNDU, Anirban (Calcutta University); MOULTAKA, Gilbert (L2C Montpellier, UMR5221-UM2/INP/CNRS); Dr MONDAL, Poulami (Kanpur University)

Orateur: MOULTAKA, Gilbert (L2C Montpellier, UMR5221-UM2/INP/CNRS)

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