



Contribution ID: 85

Type: Parallel talks

## The Decay $A^0 \rightarrow hZ^*$ in the Inverted Hierarchy and the Production for $A^0$ at the LHC in Normal Hierarchy in 2HDM

Wednesday 19 July 2023 16:20 (20 minutes)

Searches are being carried out at the Large Hadron Collider (LHC) for the decay of the CP-odd scalar ( $A^0$ ) in Two-Higgs-Doublet Models (2HDMs) with Natural Flavour Conservation (NFC) in the channel  $A^0 \rightarrow h^0 Z^*$  (with  $m_{h^0} = 125\text{GeV}$  and Z on-shell). In the absence of any signal, limits on the parameter space of  $[\tan\beta, \cos(\beta - \alpha), m_{A^0}]$  in each 2HDM are derived from  $m_{A^0} > 225\text{GeV}$ . In this work we consider the scenario of inverted hierarchy with  $m_{h^0} < 125\text{GeV}$  and  $m_{H^0} = 125\text{GeV}$  in which the decay  $A^0 \rightarrow h^0 Z^*$  (i.e. including the case of an off-shell Z) can have a large branching ratio in the 2HDM (Type I) for  $m_{A^0} < 225\text{GeV}$ . We calculate the signal cross section  $\sigma(gg \rightarrow A^0) \times BR(A^0 \rightarrow h^0 Z^{(*)}) \times BR(h^0 \rightarrow b\bar{b})$  in the 2HDM (Type I) with NFC and compare its magnitude with the cross section for the case of normal hierarchy ( $m_{h^0} = 125\text{GeV}$ ) that is currently being searched for at the LHC. For the experimentally unexplored region  $m_{A^0} < 225\text{GeV}$  it is shown that the above cross section for signal events in the scenario of inverted hierarchy can be of the order of a few picobarns. Such sizeable cross sections are several orders of magnitude larger than the cross sections for the case of normal hierarchy, thus motivating an extension of the ongoing searches for  $A^0 \rightarrow h^0 Z^*$  to probe the scenario of inverted hierarchy.

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