Why the search for $ggF/bb \to H_3 \to H_{SM} + H_S$ is more promising than $ggF/bb \to H_3 \to H_{SM} + H_{SM}$

Trilinear scalar couplings have dimension of a mass

A bit of group theory, using that H_3 and H_{SM} are SU(2) doublets:

Coupling $H_3 \times H_{SM} \times H_{SM}$: 3 SU(2) doublets contain no singlet

$\to$ Such a coupling cannot exist in the Lagrangian, it must originate from a quartic coupling involving another doublet which aquires a VEV (the SM-like Higgs after diagonalisation of the Higgs mass matrix)

$\to$ It is bounded from above by (dim.less coupling const.)$\times$(Higgs VEV)

Coupling $H_3 \times H_{SM} \times H_S$: 2 SU(2) doublets contain a singlet

$\to$ Such a coupling can exist in the Lagrangian and can be a large parameter, or originate from a large singlet VEV

$\to$ the $BR(H_3 \to H_{SM} + H_S)$ can be dominant!

This argument applies to the NMSSM and to non-susy 2HDM+singlet extensions of the Higgs sector

A large $BR(H_3 \to H_{SM} + H_S)$ alleviates constraints from (MSSM-) searches for $pp \to H_3 \to \tau^+\tau^-$ in the $M_A - \tan\beta$ plane

$\to$ A promising search, similar to resonant H_{SM} pair production but now involving two unknown masses M_{H_3} and M_{H_s}

Searches in various final states are possible, sensitivities will depend on M_{H_s} which may be smaller or larger than 125 GeV.
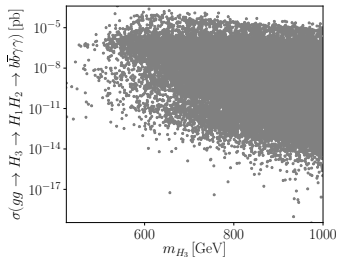
Searches will automatically be sensitive also to pseudoscalars in $pp \to A_2 \to H_{SM} + A_S$.

NMSSM benchmark planes "signal rates vs. masses" for various final states; e.g. $H_3 \to H_{125} + H_S \to b\bar{b}\gamma\gamma$

From Phillip Basler (KIT Karlsruhe/ M. Mühlleitner, preliminary):
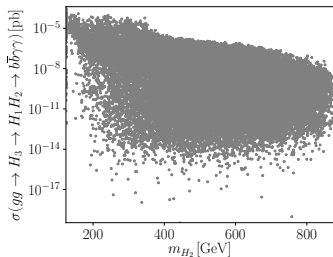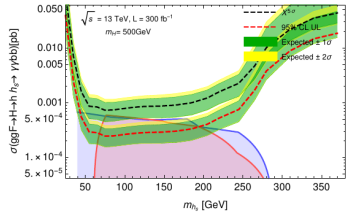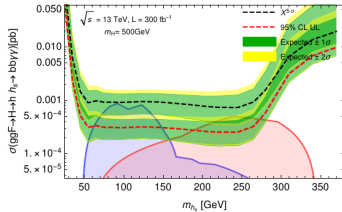

Sum over M_{H_3}

Sum over M_{H_2}

From M. Rodríguez-Vázquez (LPT Orsay/ U. Ellwanger, 1707.08522), incl. estimated sensitivities after 300 fb^{-1}:

$M_{H_3} = 500$ GeV, $\gamma\gamma$ from H_S $\gamma\gamma$ from H_{SM}

Blue: $H_3 \to H_{125} + H_S$, red: $A_2 \to H_{125} + A_S$

$\to$ At least in the NMSSM it appears that such searches are sensitive to viable regions in the parameter space already after 300 fb^{-1}

$\to$ In more general 2HDM+singlet extensions of the Standard Model viable regions in the parameter space will be larger!