Searches for additional Higgs bosons

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on behalf of the CMS collaboration

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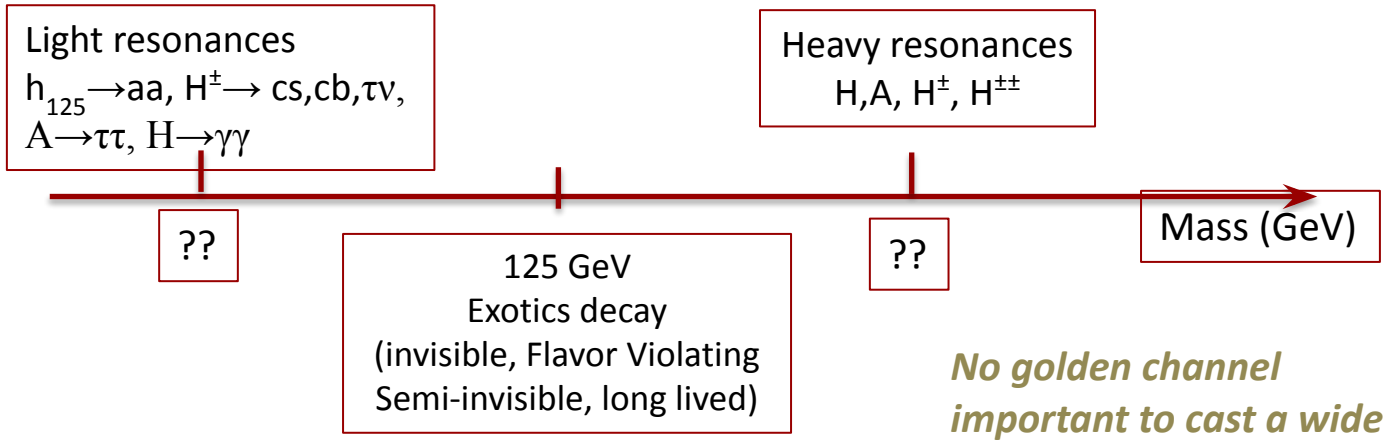
Introduction into Exotic Higgs Sector

Extended phenomenology from theoretical models (Higgs SM sector + *scalar, doublet, triplet …*)
→ Direct searches @ collider complementary to indirect constraints (b->s γ , g-2) and connected to BSM (i.e. dark matter)

Full coverage of a broad mX range is crucial to maximize the sensitivity to different models



No golden channel
important to cast a wide net

Additional bosons, CMS Run2 LHC results

3rd generation fermion, motivated by the large yukawa coupling in the SM

- $A/H \rightarrow tt$: Eur. Phys. J. C 77 (2017) 578
- $A/H \rightarrow bb$: JHEP 08 (2018) 113
- $H^{\pm} \rightarrow tb$: JHEP 2020:096 + JHEP 2020:126
- $A/H \rightarrow \tau\tau$ *JHEP 09 (2018)007*
- $H^{\pm} \rightarrow \tau_h \nu$ *JHEP 2019:142*

not a fundamental symmetry, search exists also in other decay channel

- $A/H \rightarrow \mu\mu$: Phys. Lett. B 798 (2019)
- $H^{\pm} \rightarrow$ cs,cb: Phys. Rev. D 102, 072001 (2020)

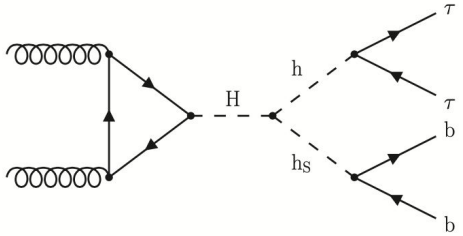
to diboson

- $A \rightarrow Zh \rightarrow (ll,\nu\nu)bb$ Eur. Phys. J. C 79 (2019)
- $H/A \rightarrow Z(ll)A/H(bb)$ JHEP 03 (2020) 055
- High Mass $H \rightarrow WW$ JHEP 03 (2020) 034
- $H^{+} \rightarrow Wa$ Phys. Rev. Lett. 123, 131802 (2019)

Data not showing evidence of theory with 2HDM
→ more complicated theory scenario proposed i.e. Higgs Triplets or 2HDM+Scalar
⇒ this talk report on two searches to test those new structures of BSM

NMSSM

HIG-20-014 Submitted to JHEP
https://arxiv.org/abs/2106.10361



$H/A_{MSSM} \rightarrow h_s(bb) + h_{125}(\tau\tau)$

motivated by SM extensions such as $SU2_{MSSM}$+ S

→ Categorization based on that tau decay mode ($\tau_e\tau_h$, $\tau_u\tau_h$,$\tau_h\tau_h$),

→ DEEP Neural network used for τ and b-jets identification

→ Neural network multiclassifier:

discriminator used for maximum likelihood fit for signal extraction

NMSSM

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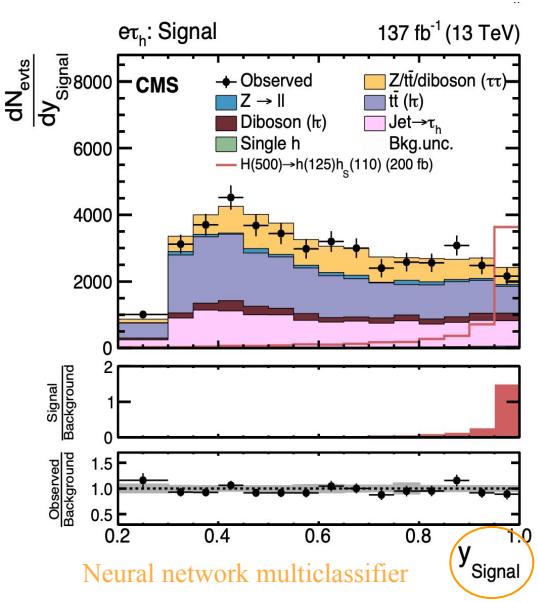
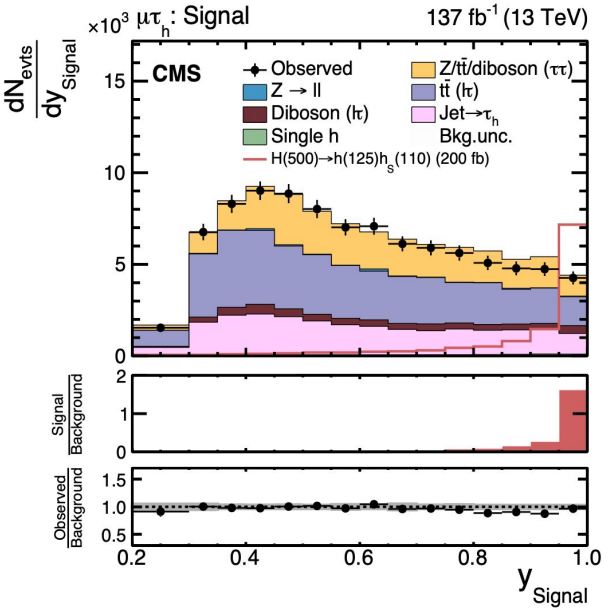
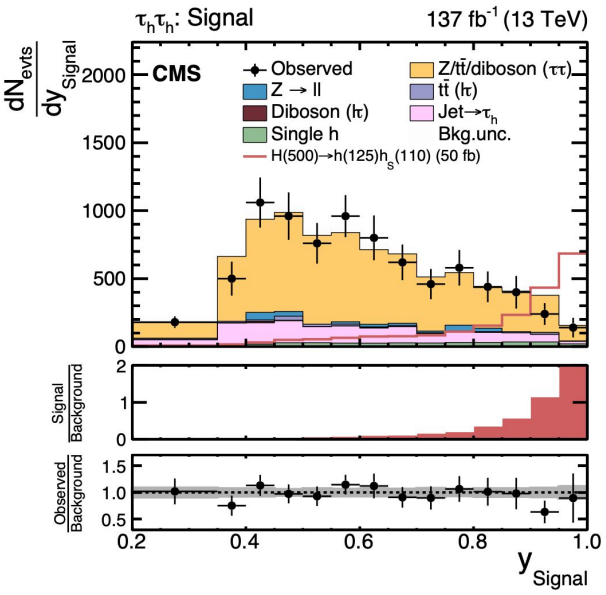
major backgroud:
real hadronic tau from embedding simulated tay in Zmm events
jet → hadronic tau from fake rate probability
events with at least one W/Z decaying into e/m from MC simulation



Neural network multiclassifier





$H/A_{MSSM} \rightarrow h_s(bb) + h_{125}(\tau\tau)$

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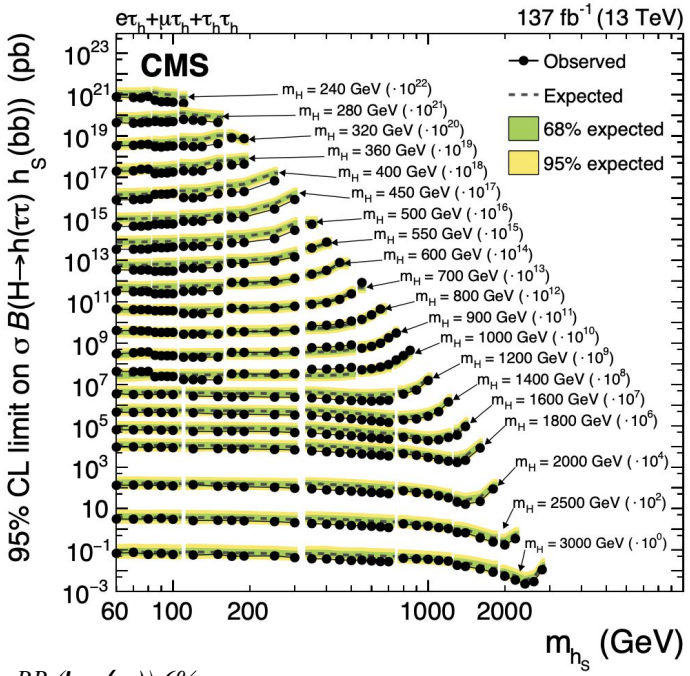
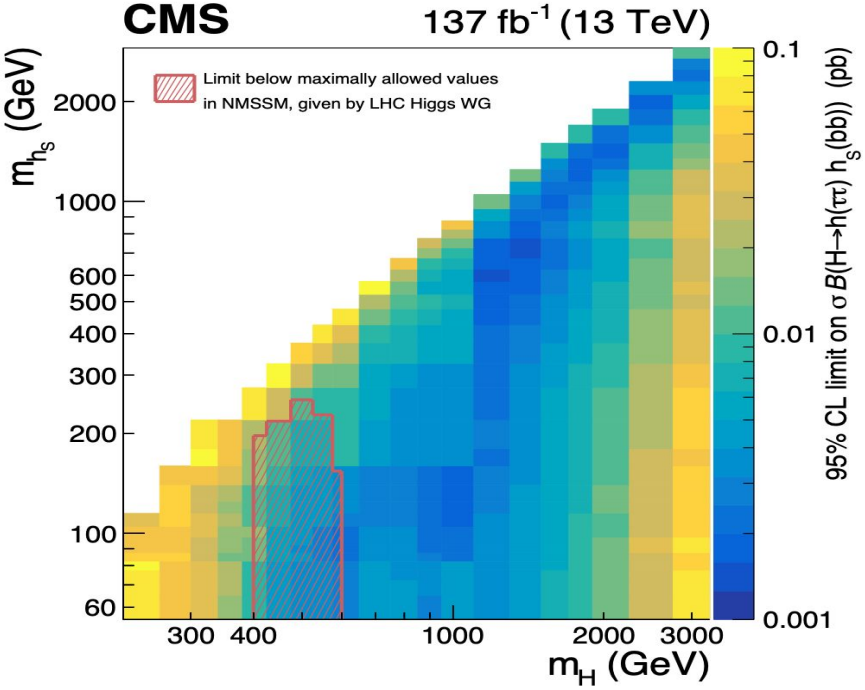
Upper limits on h_s from (m_H = 240 GeV) to 2.7 fb (m_H = 3 TeV)



BR ($h_{125}(\tau\tau)$) 6%

→ improvements possible exploring other decay mode

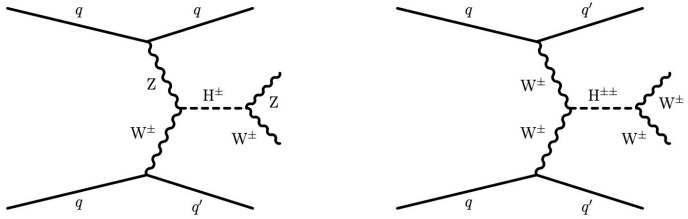


Constrained for masses of m_H ~400-620 GeV and mh_s ~60-250 GeV

Heavy Charged Higgs to bosons

HIG-20-017 *accepted by EPJC*
https://arxiv.org/abs/2104.04762

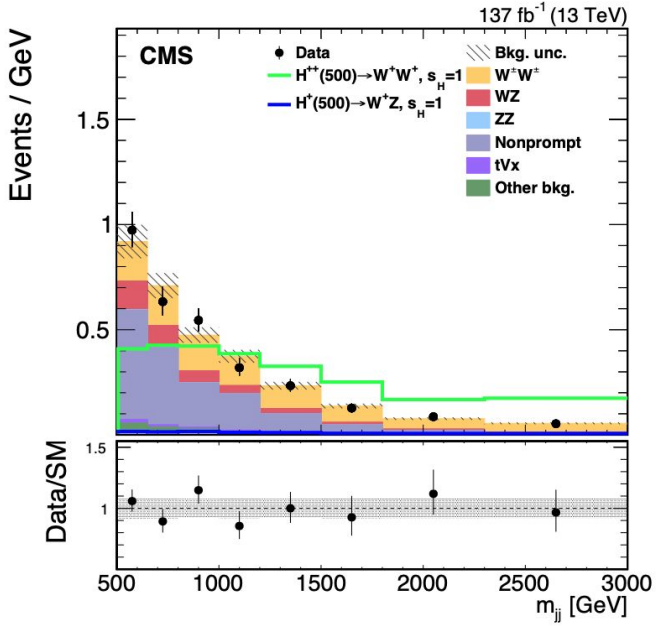
Motivated by Georgi-Machacek model with two SU(2)L-triplet scalars to the Standard Model in such a way as to preserve custodial SU(2) symmetry.

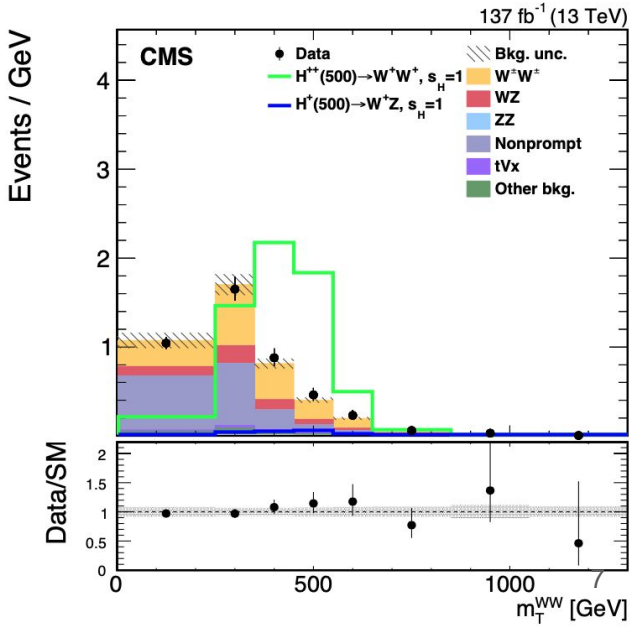


Clean signature: same sign and 3l final state + two VBFjets search in bin of Mjj and M_T^{VV}

Background divided in three classes:

- ➢ WW and WZ measured in situ
- ➢ Non prompt / Fakes from data CR
- ➢ Prompt irreducible from MC:
  - ○ measured in the CR with ZZ and tZq

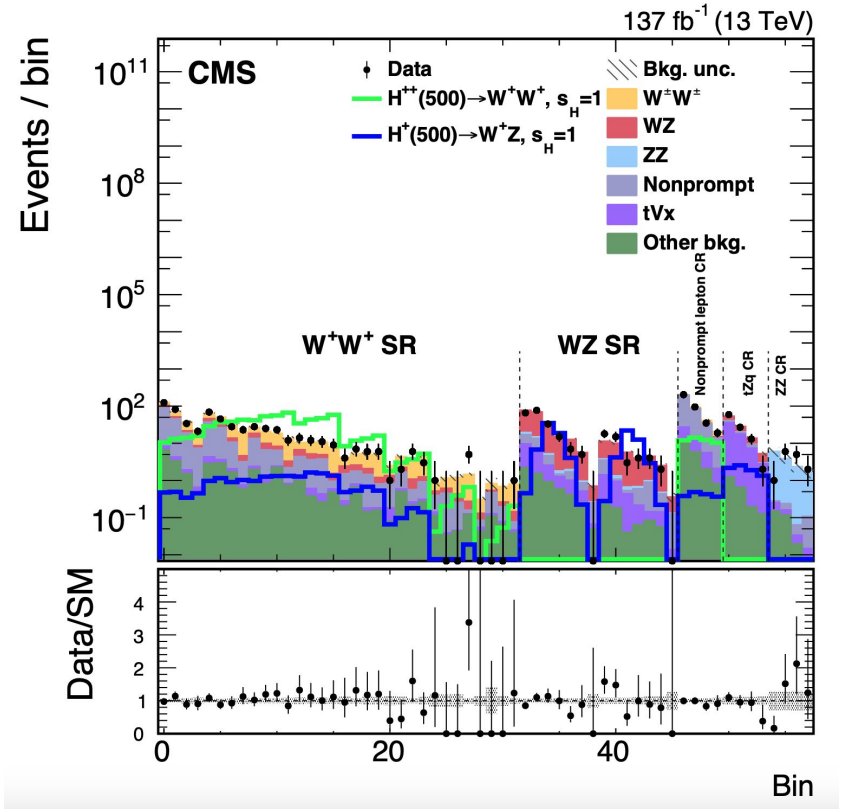




ATLASD similar final state non in VBF mode:
JHEP 06 (2021) 146

Heavy Charged Higgs to bosons

Distributions for signal, backgrounds, and data for the bins used in the simultaneous fit.



Heavy charged higgs to bosons

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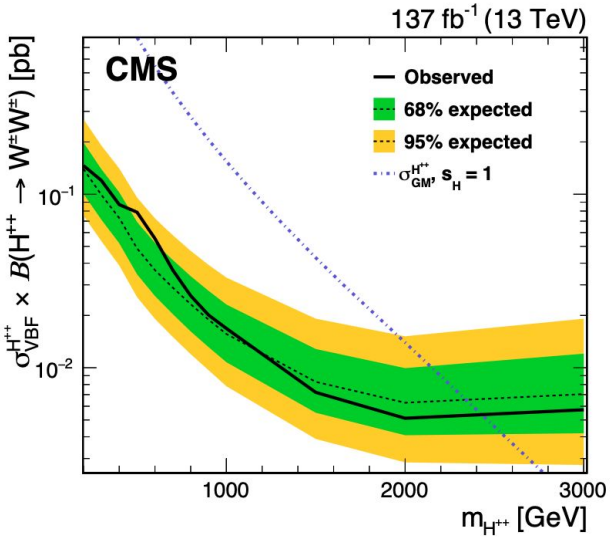
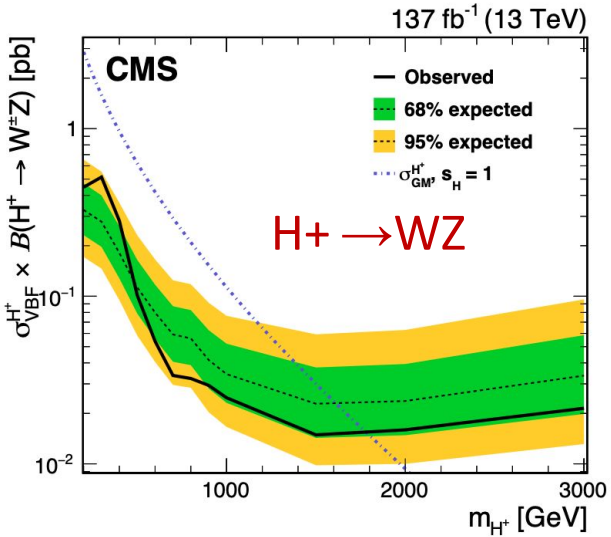
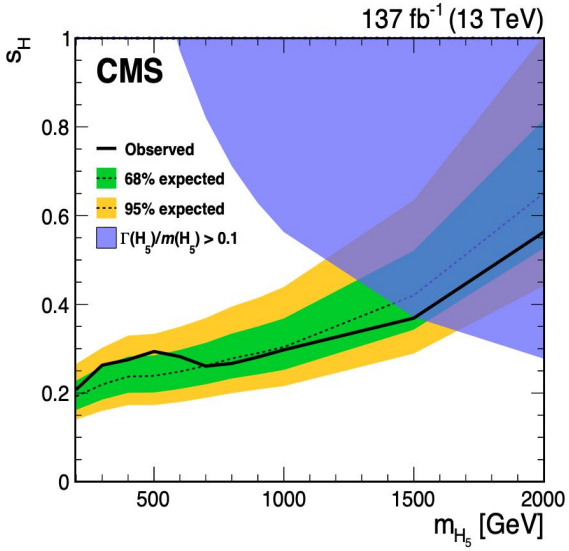
$H^{+/-+/-} \rightarrow W^{+/-+/-}W^{+/-+/-}$







Exclusion with m_{H++} ~ 2.5 TeV of , m_{H+} 2 ~TeV

Outlook

Improved techniques beyond the increase in luminosity

More direct search for additional Higgs bosons above and below 125 GeV expected with the full LHC luminosity

Complement direct searches with measurement of the SM couplings modifications