



Universität Hamburg
DER FORSCHUNG | DER LEHRE | DER BILDUNG

CLUSTER OF EXCELLENCE
QUANTUM UNIVERSE

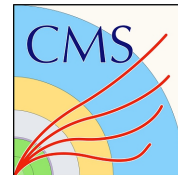


Bundesministerium
für Forschung, Technologie
und Raumfahrt

Gefördert durch:



FSP CMS
Erforschung von
Universum und Materie



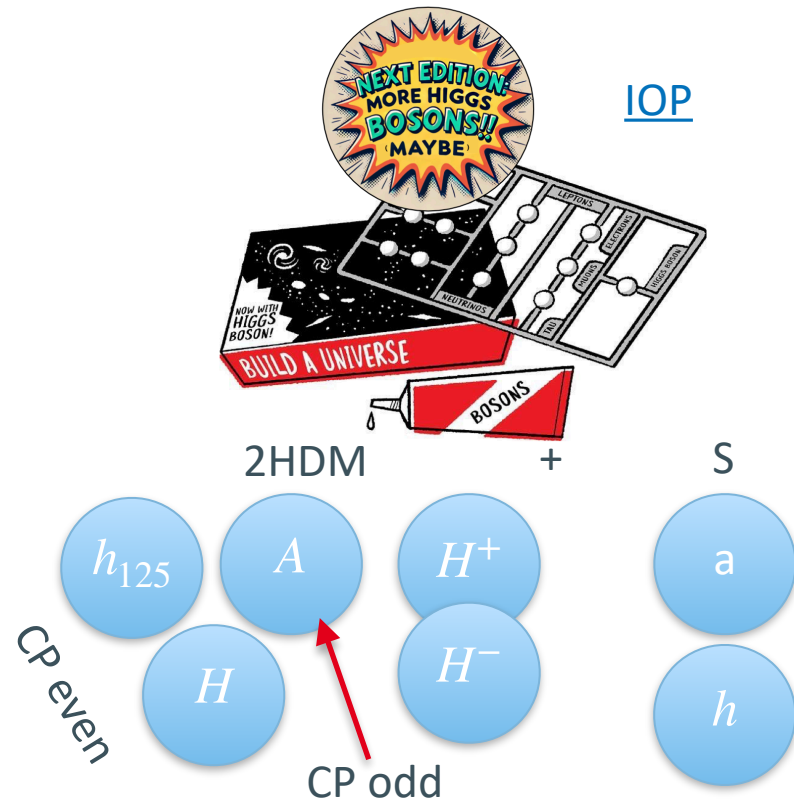
Yannick Fischer (Universität Hamburg) on behalf of the CMS collaboration

Searches for additional Higgs bosons at CMS

EPS-HEP 2025 in Marseille, 09.07.2025

Many BSM theories: additional Higgs bosons, e.g. 2HDM, NMSSM, composite Higgs

Simplest extension:
add doublet $\rightarrow$ 5 Higgs bosons
further add singlet $\rightarrow$ 7 Higgs bosons

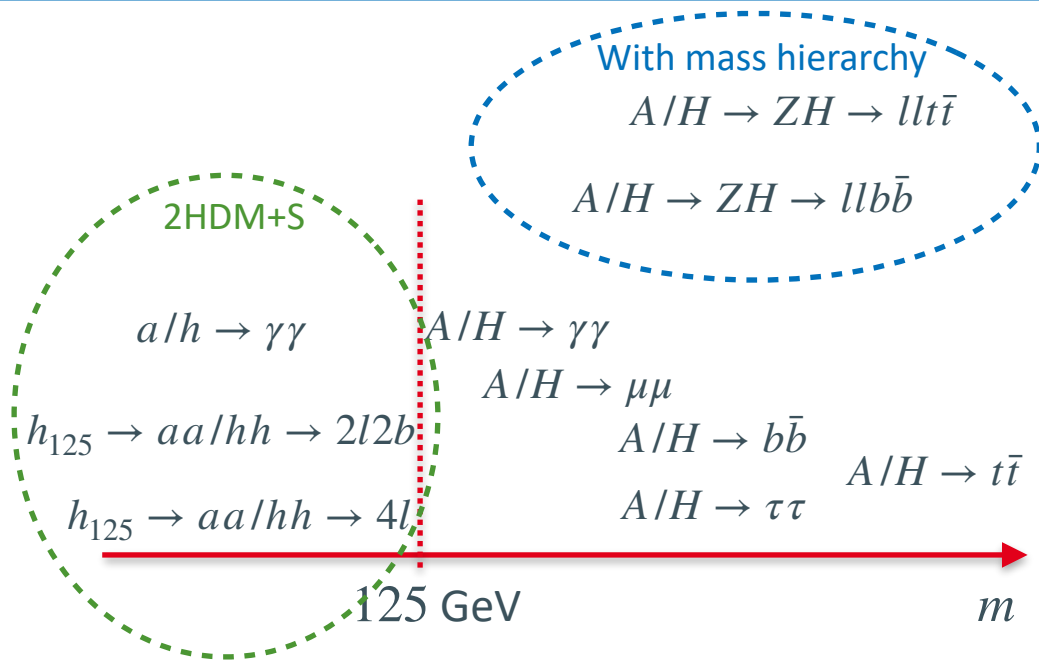


CMS searches for additional Higgs bosons



- Several searches performed during run 2:

- $A/H \rightarrow \gamma\gamma$:
 - [Phys. Lett. B 860 \(2025\) 139067](#) (low mass)
 - [Phys. Rev. D 98 \(2018\) 092001](#) (high mass)
 - [CMS PAS HIG-24-014](#) (low mass) *NEW!*
- $A/H \rightarrow \tau\tau$: [JHEP 09 \(2018\) 007](#)
- $A/H \rightarrow t\bar{t}$: [JHEP 04 \(2020\) 171](#)
- $A/H \rightarrow b\bar{b}$:
 - [JHEP 09 \(2018\) 113](#)
 - [CMS-SUS-24-001](#) *NEW!*
- $A/H \rightarrow \mu\mu$: [Phys. Lett. B 798 \(2019\) 134992](#)
- $A \rightarrow ZH \rightarrow llb\bar{b}$: [JHEP 03 \(2020\) 055](#)
- $A \rightarrow ZH \rightarrow llt\bar{t}$: [Phys. Lett. B 866 139568 \(2025\)](#) *NEW!*
- $h_{125} \rightarrow aa/hh$:
 - [Phys. Lett. B 785 \(2018\) 462](#) ($2\tau 2b$)
 - [Phys. Lett. B 795 \(2019\) 398](#) ($2\mu 2b$)
 - [JHEP 11 \(2018\) 018](#) ($2\tau 2\mu$)
 - [Phys. Lett. B 796 \(2019\) 131](#) (4μ)
 - [CMS PAS SUS-24-002](#) (4τ) *NEW!*

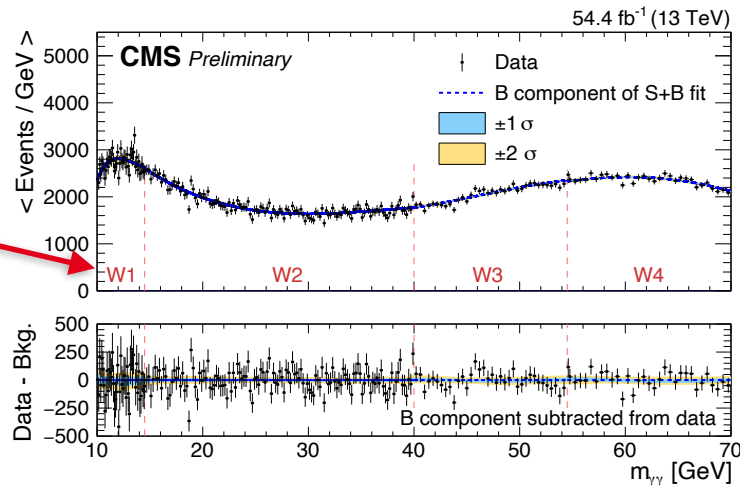
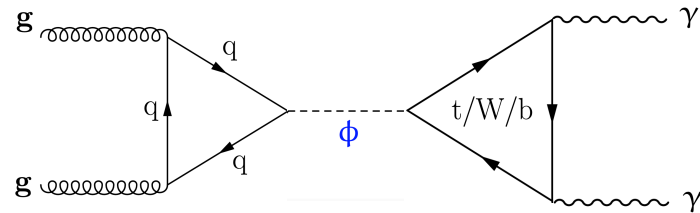


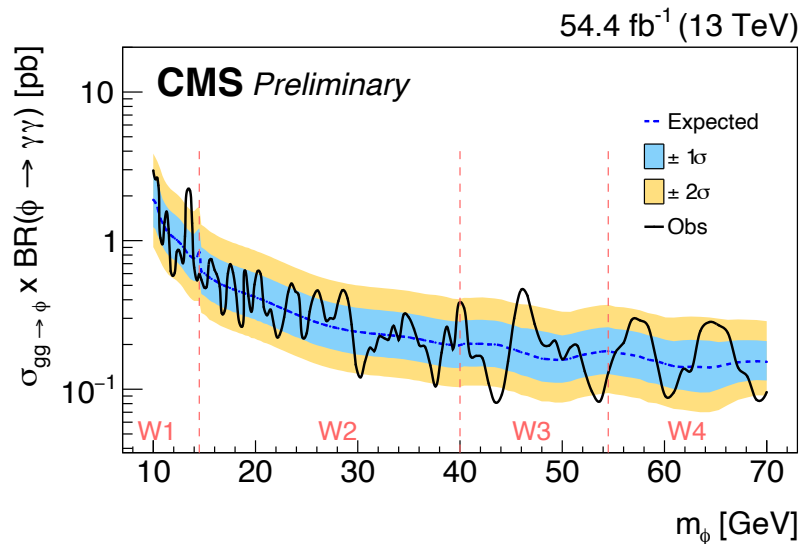
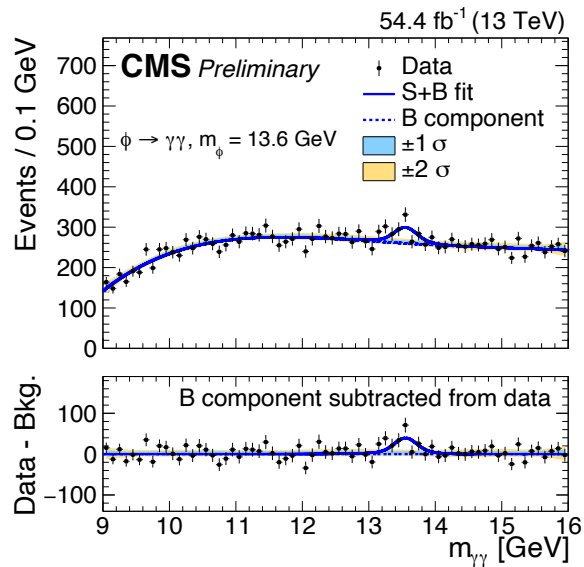
$$h/a \rightarrow \gamma\gamma$$



Minimal set of model dependent assumptions
→ very broad search

- Search for resonances in $m_{\gamma\gamma}$ between 10 GeV and 70 GeV
- Analysis strategy:
 - Split mass range into **four regions**
 - Model signal+background (from mass sidebands) separately in each region

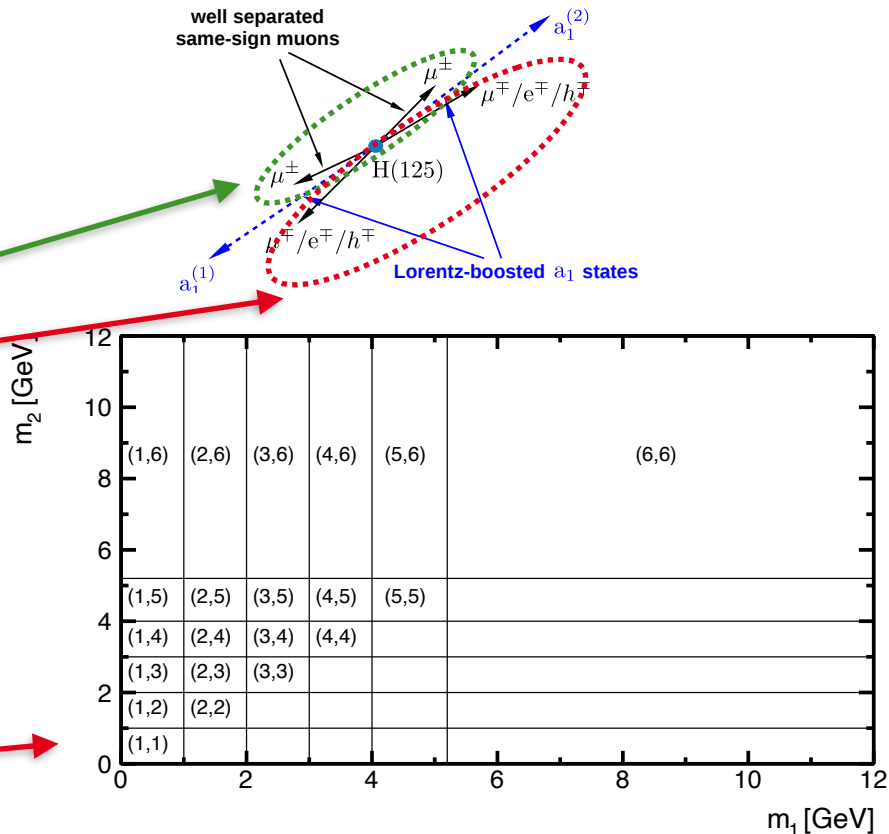




- Largest excess observed at 13.6 GeV with local significance of 3.5σ
 $\rightarrow$ global significance at $(1.9 \pm 0.1)\sigma$

$$h_{125} \rightarrow aa \rightarrow 4\tau$$

- Large mass gap $\rightarrow$ highly boosted regime
- Targeted final state: 2 same-charge muons + close-by electron, muon or charged hadron
- Main background: QCD multijet modeled from several CRs in data
- Sensitive variable: reconstructed masses in 2D bins

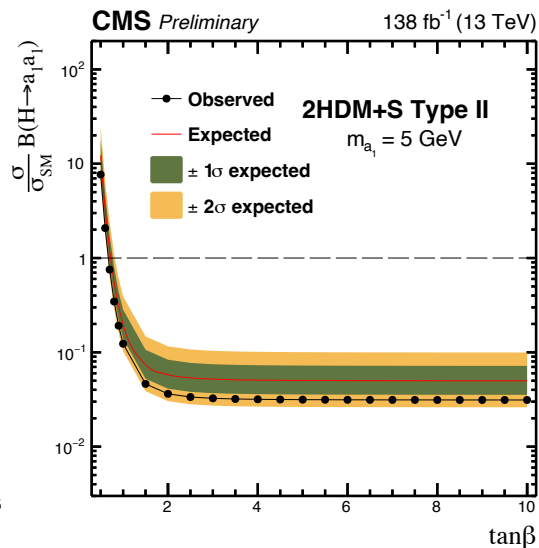
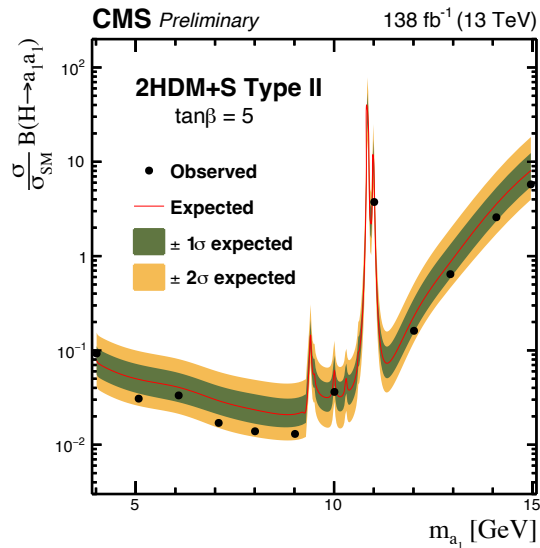
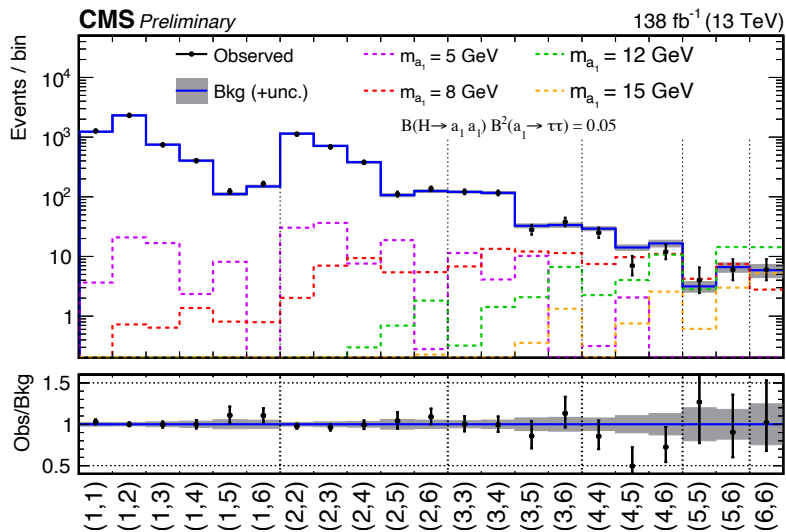


$h_{125} \rightarrow aa \rightarrow 4\tau$

- No significant excesses observed
- Interpretation in various 2HDM+S models

[Phys. Lett. B 800 \(2020\) 135087](#)

2 to 4 times better sensitivity than previously achieved

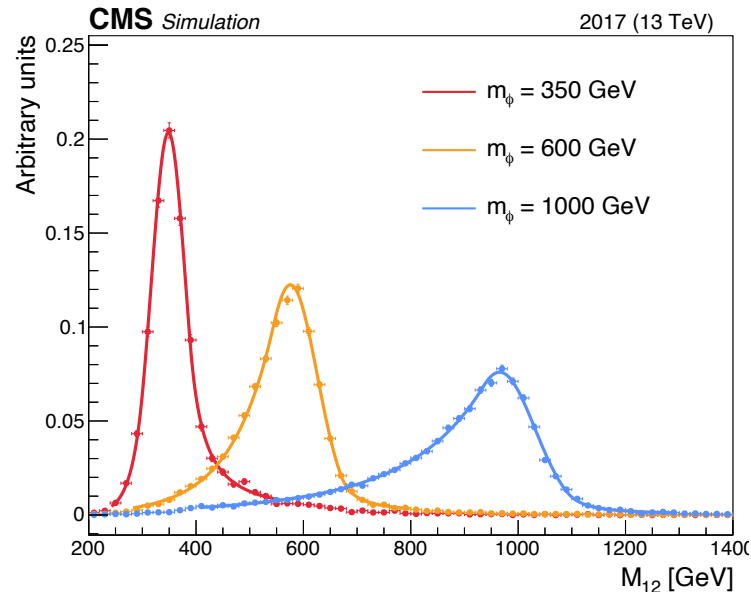
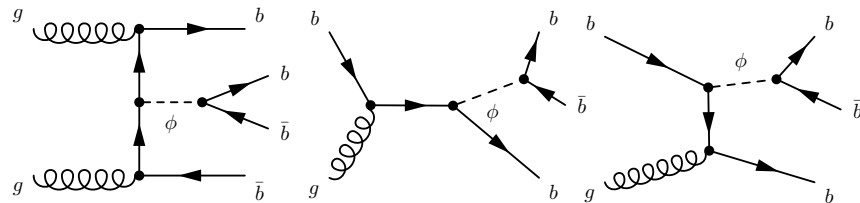


$$H \rightarrow b\bar{b}$$

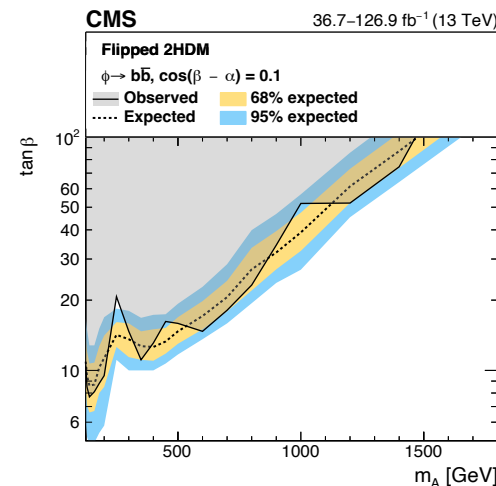
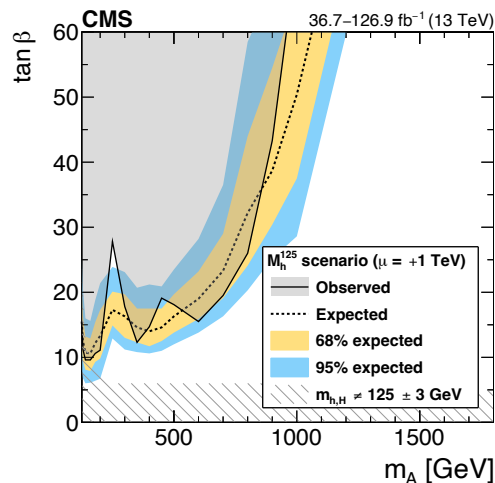
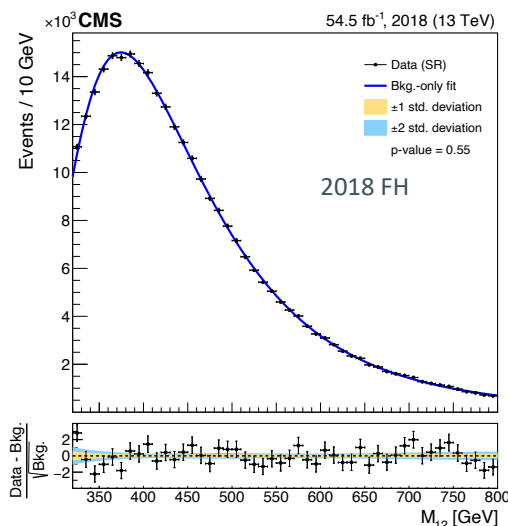


Particularly sensitive to flipped 2HDM models

- Targeting heavy Higgs bosons produced in **association** with at least **one b quark**
- Main background: heavy-flavor multijet production modeled from CR in data
- Analysis targets decays with zero (FH) and one (SL) muon inside of b quark cone using M_{12} invariant mass of leading b jets



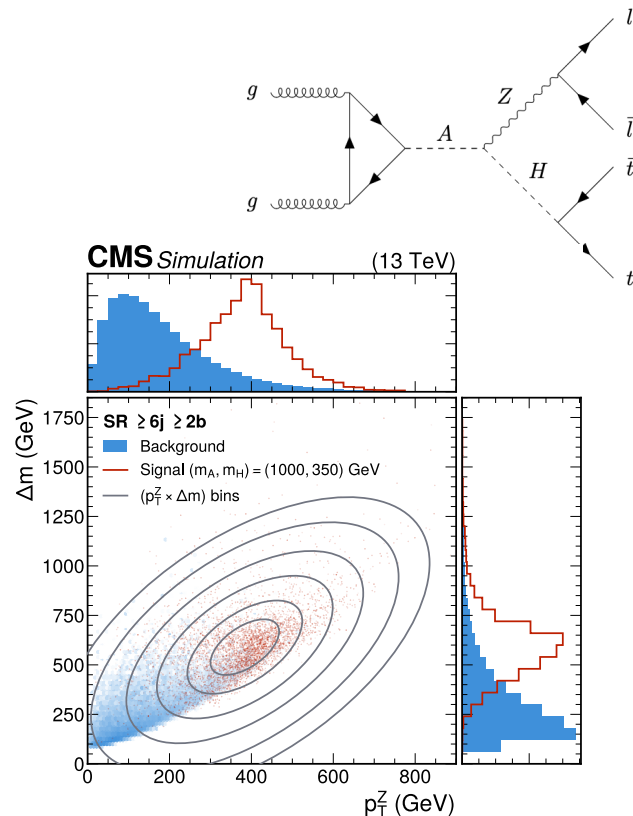
- No significant excesses from SM observed
- Results from this analysis (2017+2018) combined with previous analysis of 2016 data ([JHEP 09 \(2018\) 113](#))
- Interpretation of 2HDM & MSSM limits derived, excluding masses up to 1.5 TeV



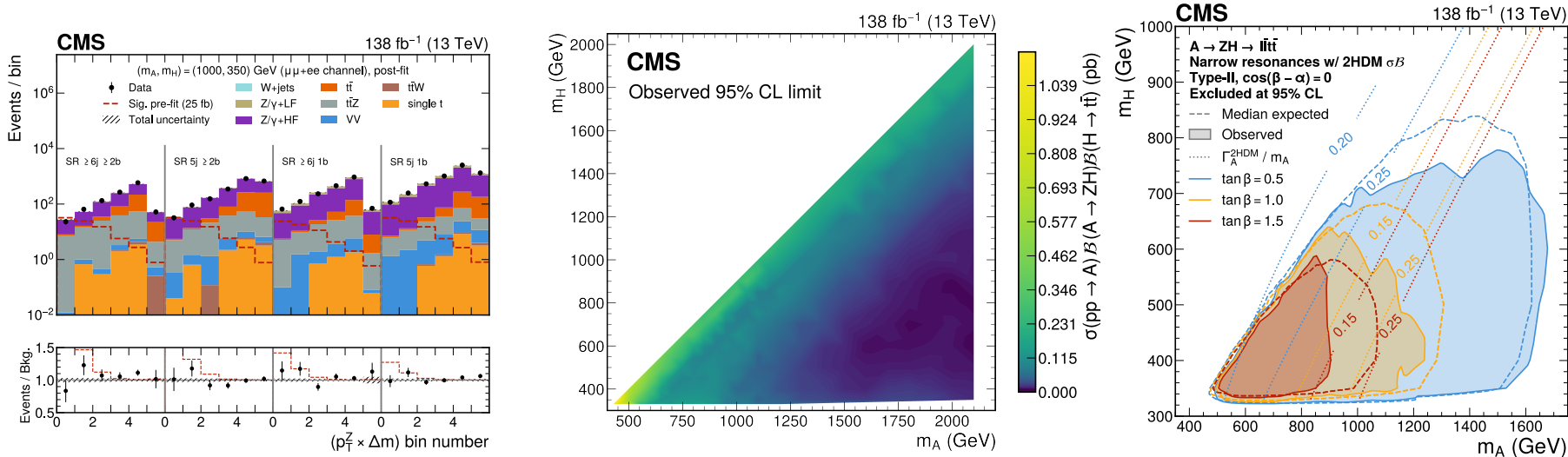
$$A \rightarrow ZH \rightarrow llt\bar{t}$$

Probing parameter space relevant
in models of baryogenesis

- Heavy Higgs A decaying into ZH further decaying into $llt\bar{t}$ with hadronic top decay
 - First search in this channel
- Main background: $t\bar{t}$ and Drell-Yan modelled in data from several CRs
- Sensitive observables p_T^Z and reconstructed invariant mass difference $\Delta m = m_A - m_H$, condensed into elliptical binning



- No significant excess observed
- Limits interpreted within 2HDM type II model $\rightarrow$ masses up to 1600 GeV excluded for $\tan(\beta) = 0.5$



Summary



- Large program of heavy Higgs searches in CMS, huge variety of final signature covered with Run 2 data
- No signal observed so far, results used to set stringent constraints on extended Higgs sectors

Stay tuned: **Run 3** data

expected to further increase sensitivity to additional Higgs bosons

