

Discussion on “BSM Higgs Searches/Rare Higgs Decays”

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Talks:

- Eleni Skorda (ATLAS)
 - Siddhesh Gopichand Sawant (CMS)
- ⇒ just a few (personally biased) examples ...

Hopefully slightly provocative ... :-)

But first an “organizational remark”

“Organizational remark”

In the previous 10 years we had:

- two ATLAS talks (BSM, rare decays)
- two CMS talks (BSM, rare decays)
- one theory talk

⇒ in total 80+’

This year:

- one ATLAS talk (BSM + rare decays)
- one CMS talk (BSM + rare decays)

⇒ in total 40’

Original idea of Luis and Nicolas:

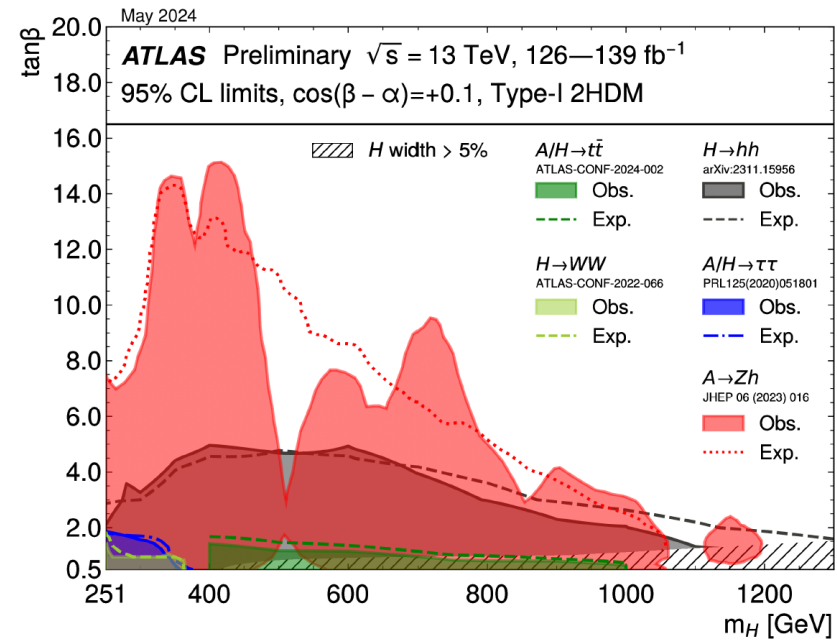
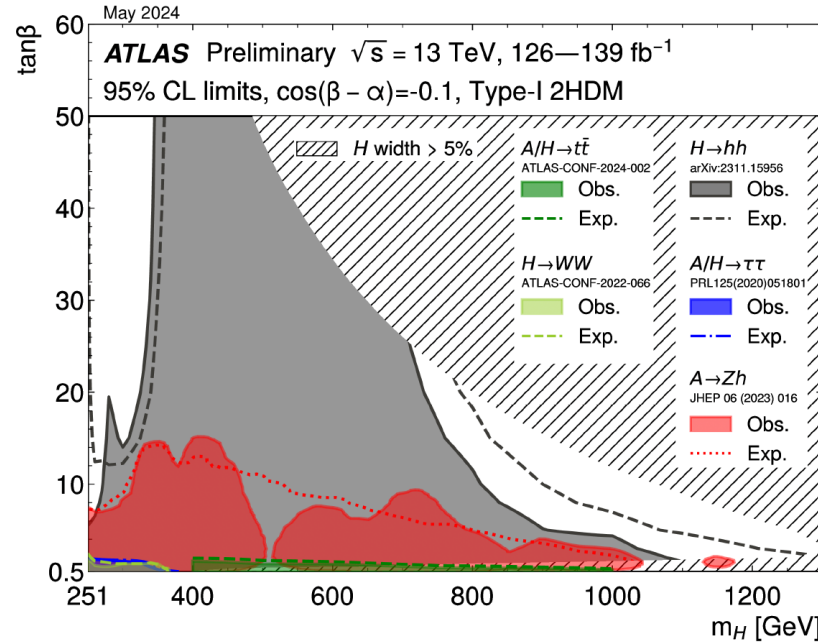
“brief overview of the theory landscape as part of your introduction”

Now I got the usual 5 minutes (one spent on this already ;-)

⇒ I hope this does not reflect the interest in BSM physics

⇒ we are here to hunt BSM Higgses!

ATLAS 2HDM type I overview:

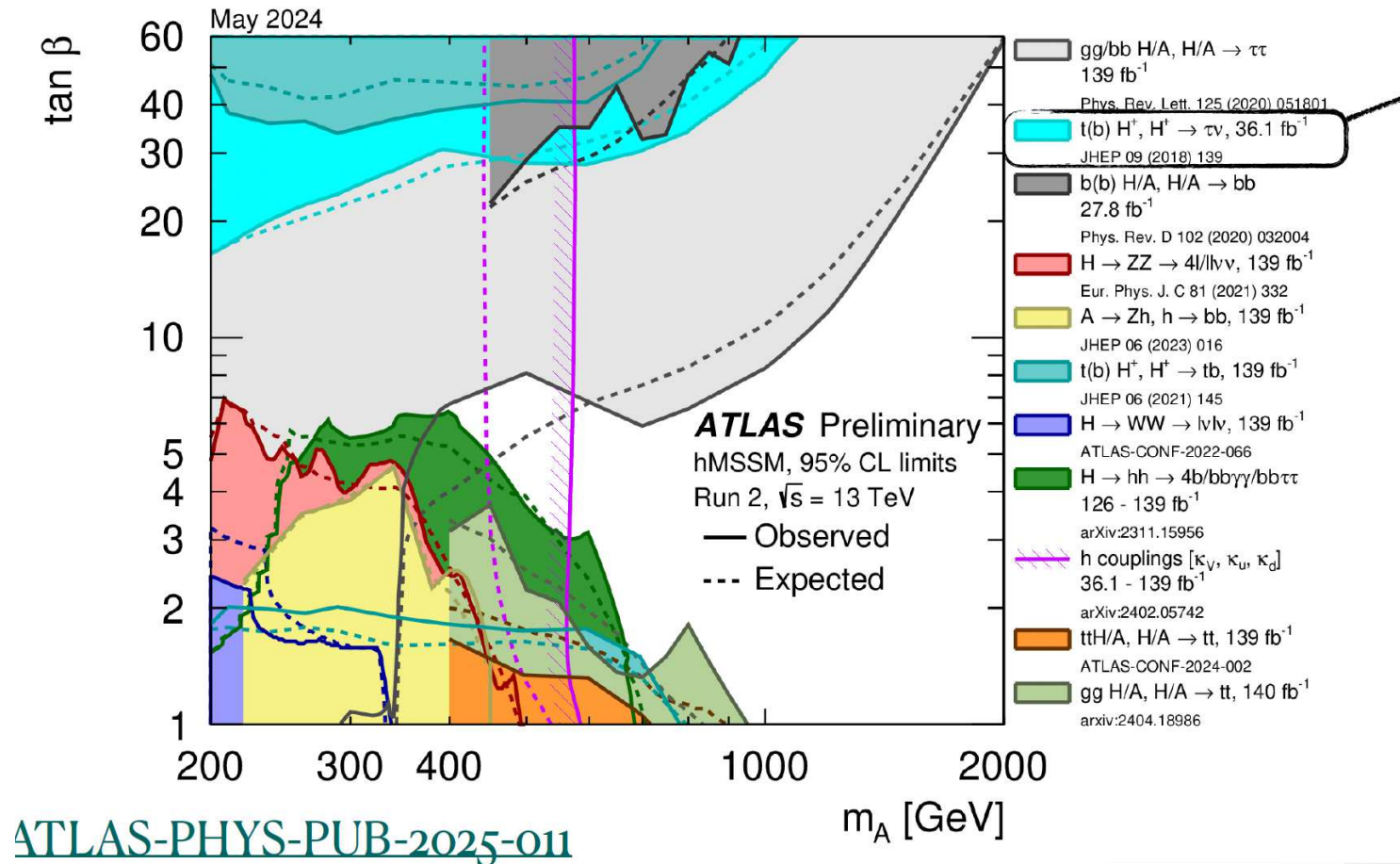


Nice, but information is missing ...

- why such difference in $H \rightarrow hh$
 - $H \rightarrow hh$ not reliable anyway (as briefly discussed yesterday)
 - what are the other parameters???
- ⇒ difficult to make use of these plots!

$$\lambda_{hhH} = \frac{-c_{\beta-\alpha}}{2v^2} \left(s_{\beta-\alpha}^2 (2m_h^2 + m_H^2 - 4\bar{m}^2) + 2s_{\beta-\alpha}c_{\beta-\alpha} \cot 2\beta (2m_h^2 + m_H^2 - 3\bar{m}^2) - c_{\beta-\alpha}^2 (2m_h^2 + m_H^2 - 2\bar{m}^2) \right),$$

Summary plots (hMSSM)



⇒ call it 2HDM type II (has hardly anything to do with SUSY)

⇒ some real SUSY analysis would be interesting ...

ATLAS: many BSM Higgs searches

Light resonances
[0.5 - 60] GeV

- $H \rightarrow aa \rightarrow \gamma\gamma\tau\tau$, [DOI: 10.1007/JHEP03\(2025\)190](https://doi.org/10.1007/JHEP03(2025)190)
- $H \rightarrow aa \rightarrow \tau\tau\tau$, [arXiv:2503.0563](https://arxiv.org/abs/2503.0563)
- $HZ, H \rightarrow \alpha\alpha \rightarrow 4b, 6b$, [arXiv:2507.01165](https://arxiv.org/abs/2507.01165)
- $H \rightarrow Za \rightarrow ll\gamma\gamma$ and $H \rightarrow aa \rightarrow 4\gamma$, [ATL-PHYS PUB-2025-007](https://atlas.cern/ATL-PHYS-PUB-2025-007)
long lived ALPS reinterpretation
- $H \rightarrow Za \rightarrow ll$ jets, [DOI: 10.1016/j.physletb.2025.139671](https://doi.org/10.1016/j.physletb.2025.139671)

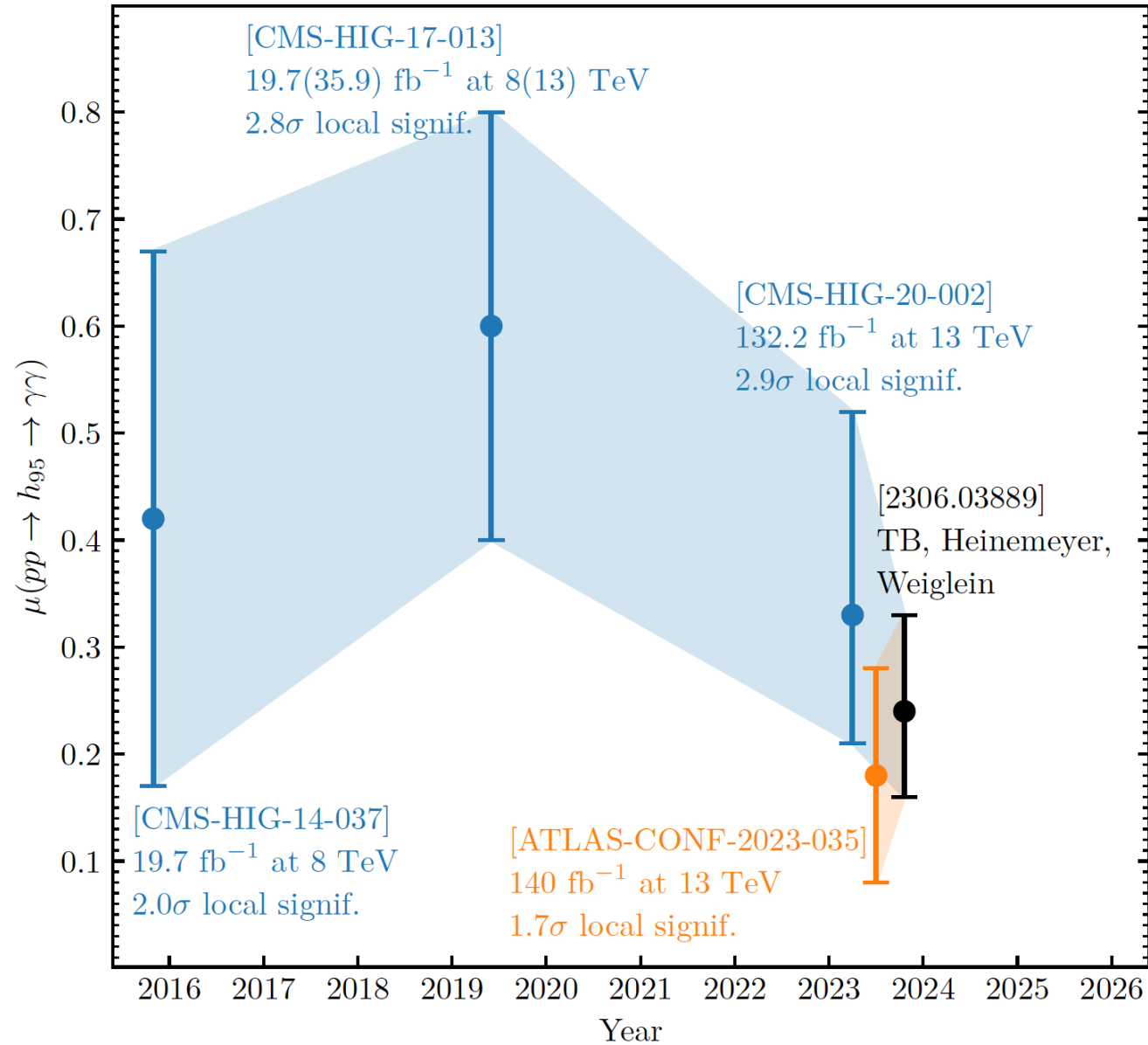
Searches exploring
higher mass ranges
30 GeV up to 3TeV

- $S \rightarrow XX \rightarrow 4\text{leptons}$, [DOI:10.1016/j.physletb.2025.139472](https://doi.org/10.1016/j.physletb.2025.139472)
- $H^\pm \rightarrow WH, H \rightarrow bb$, [DOI: 10.1007/JHEP02\(2025\)143](https://doi.org/10.1007/JHEP02(2025)143)
- $H^\pm \rightarrow \tau^\pm \nu$, [DOI: 10.1103/PhysRevD.111.072006](https://doi.org/10.1103/PhysRevD.111.072006)

⇒ great to see so much activity!

⇒ but nothing about h_{95}

⇒ no update for two years - you know how to combine Run II/III data



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CMS: many BSM Higgs searches

$H(125) \rightarrow aa$

- $H \rightarrow aa \rightarrow 4\gamma$ (boosted) [[Phys. Rev. Lett. 131 \(2023\) 101801](#)]
- $H \rightarrow aa \rightarrow 4\gamma$ (resolved) [[JHEP 07 \(2023\) 148](#)]
- $H \rightarrow aa \rightarrow \mu\mu\tau\tau$ (boosted) [[JHEP11\(2021\)057](#)]
- $H \rightarrow aa \rightarrow \mu\mu\tau\tau$ (resolved) [[JHEP11\(2018\)018](#)]
- $H \rightarrow aa \rightarrow \mu\mu bb / \tau\tau bb$ [[Eur. Phys. J. C 84 \(2024\) 493](#)]
- $H \rightarrow aa \rightarrow 4b$ [[JHEP06\(2024\)097](#)]
- $H \rightarrow aa \rightarrow 4\mu$ [[JHEP12\(2024\)172](#)]
- $H \rightarrow aa \rightarrow 4\tau$ [[CMS-PAS-SUS-24-002](#)]

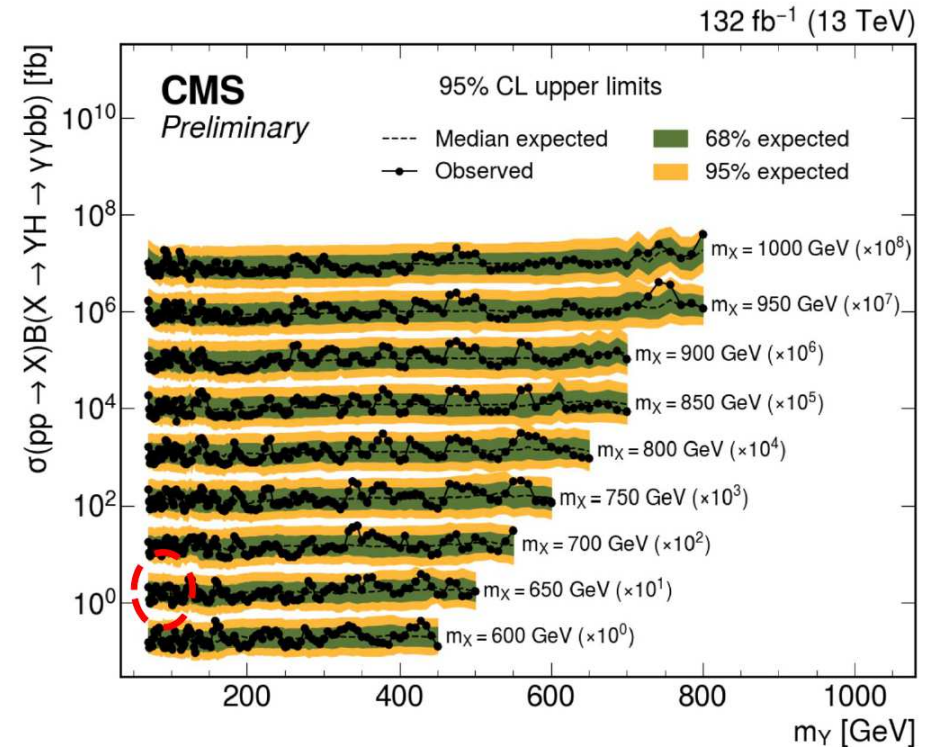
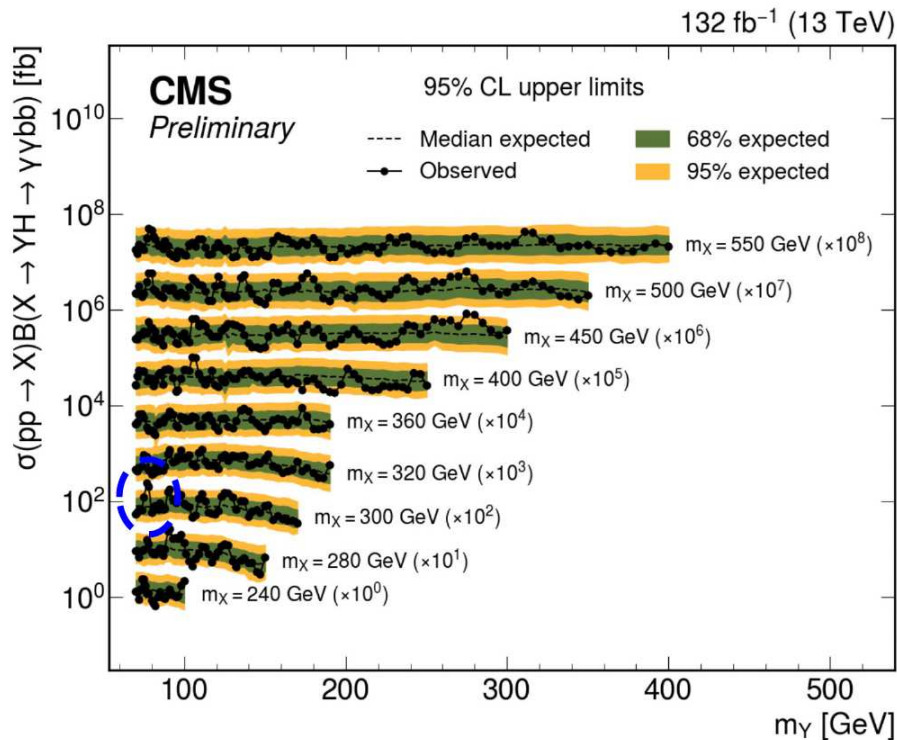
\Rightarrow great to see so much activity!

\Rightarrow comparison with ATLAS?? \Rightarrow never performed!

CMS: Higgs cascade decays

⇒ predicted by nearly all BSM Higgs models

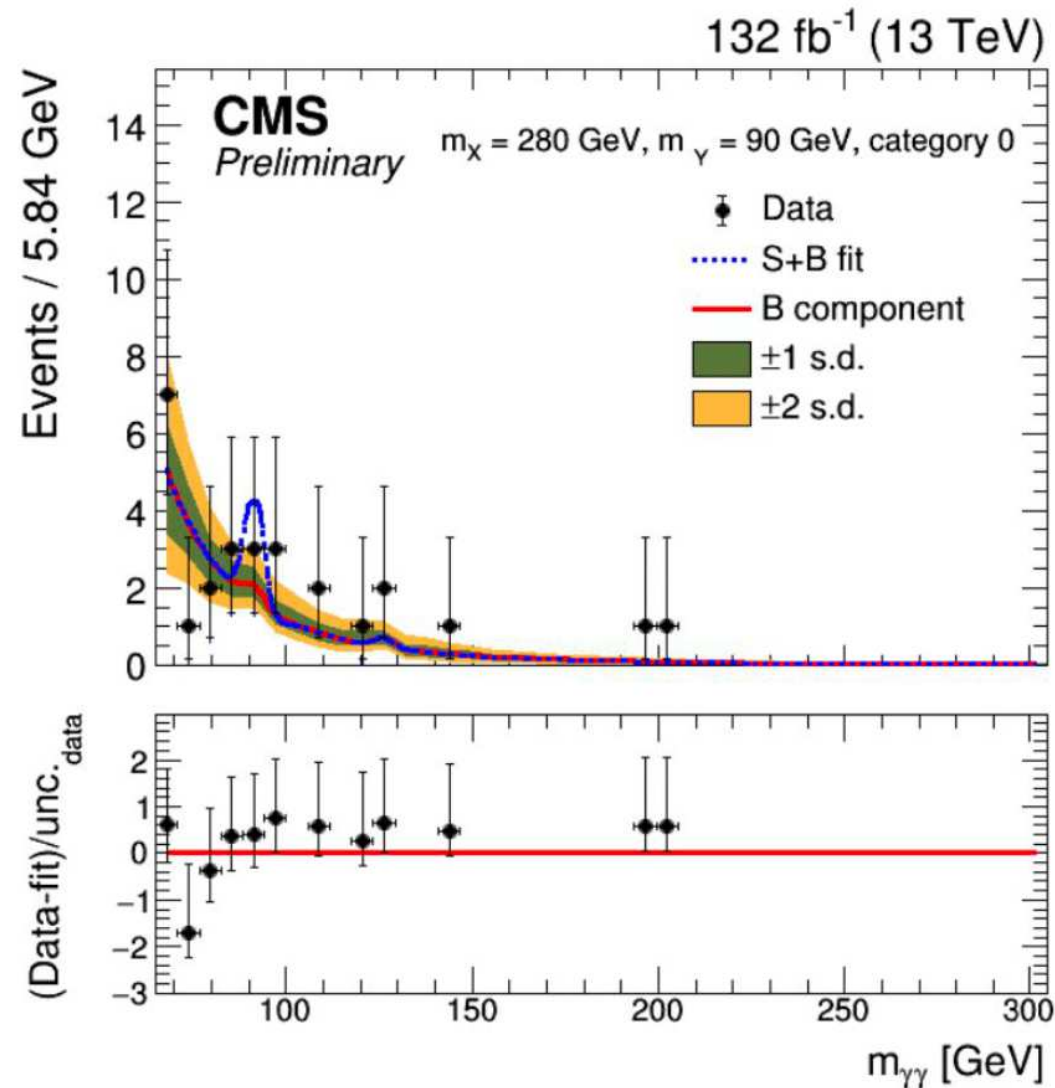
$$X \rightarrow H(bb) Y(\gamma\gamma) \text{ (III)}$$



Largest local (global) excess of 3.3 (0.6) σ significance at $m_X=300 \text{ GeV}$, $m_Y=77 \text{ GeV}$


⇒ is this really the most important conclusion here?

Finally (unintended?) some news on the h_{95} :



⇒ several other excesses around ~ 95 GeV showed up

⇒ never a combined analysis/interpretation ⇒ common systematic effect?



Further Questions?