Additional neutral heavy Higgs in fermion decays

On behalf of the ATLAS and CMS collaborations

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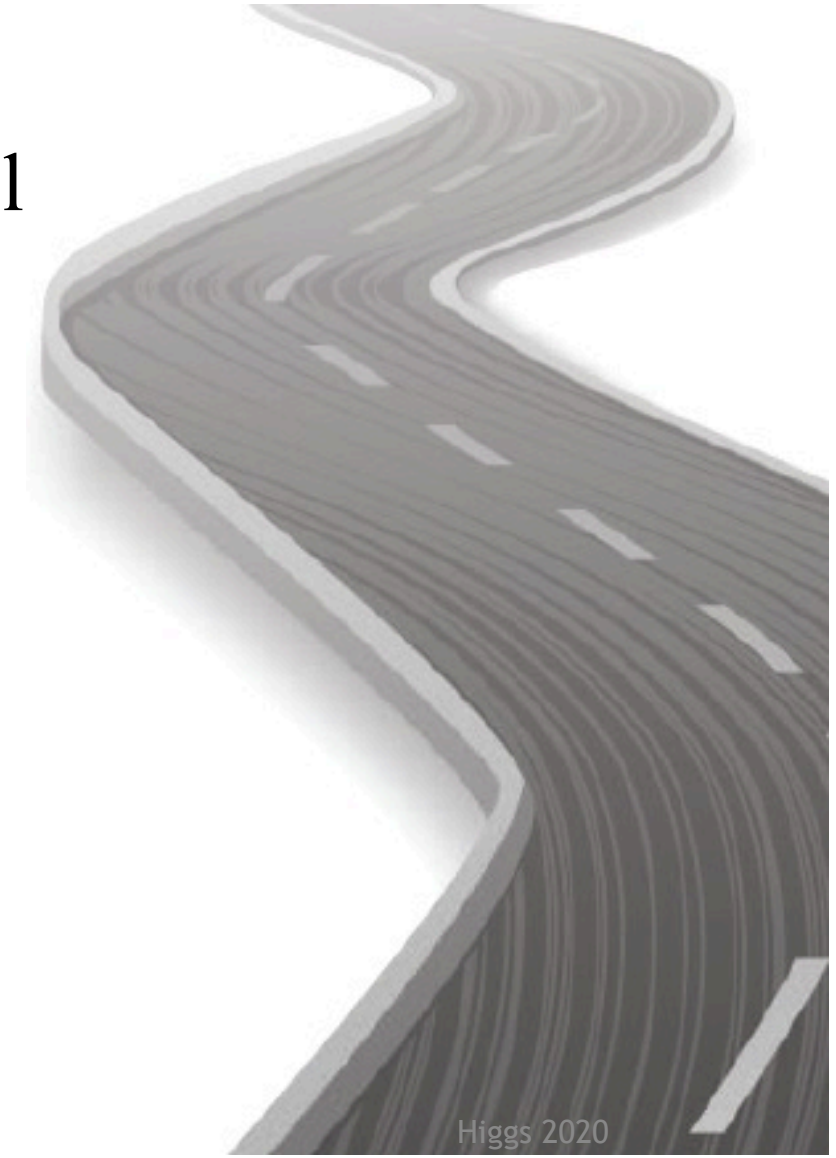
Higgs2020

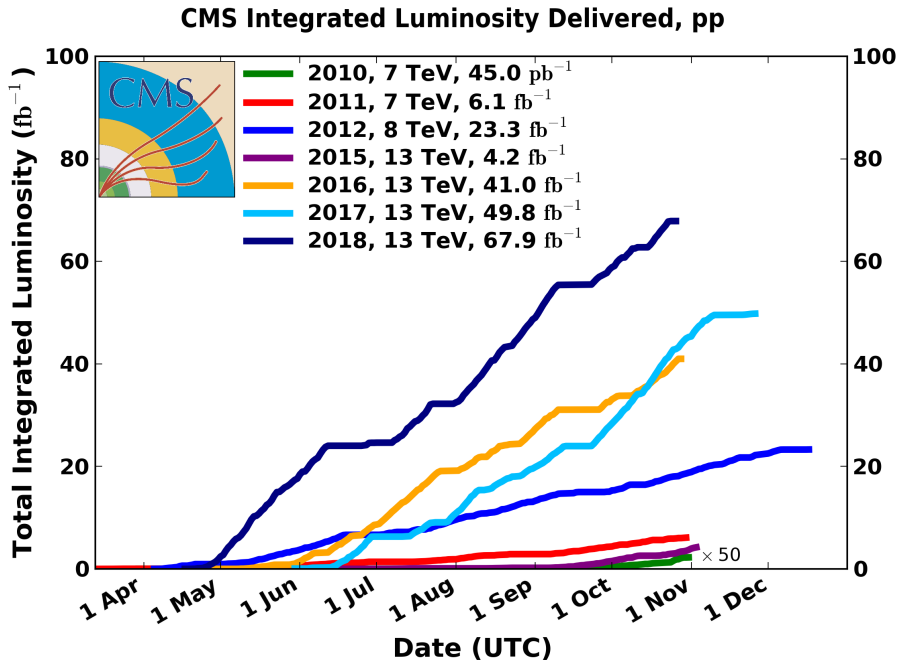
Outline

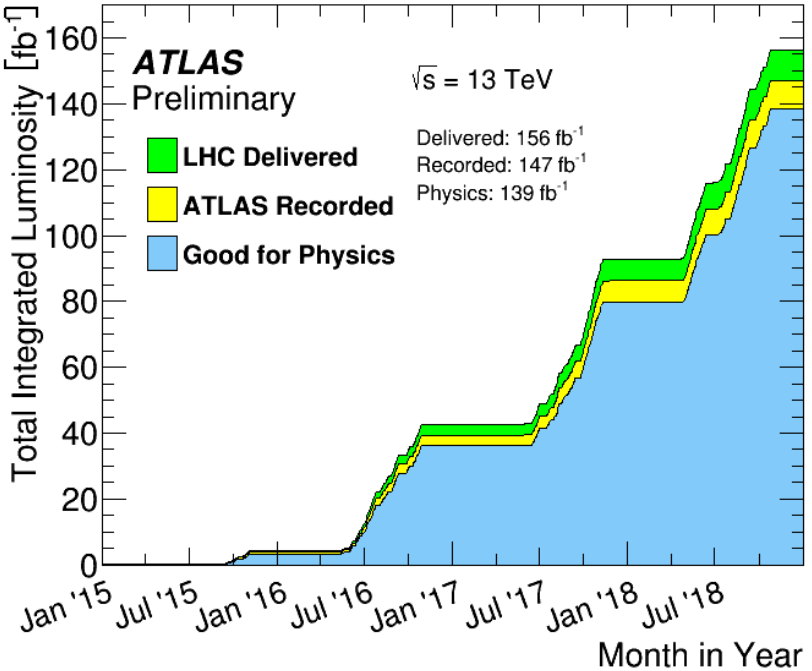
- The LHC
- Beyond the Standard Model
- Fermionic Decays
  - $\tau\tau$
  - $t\bar{t}$
  - $\mu\mu$
  - $b\bar{b}$
- Summary



The LHC

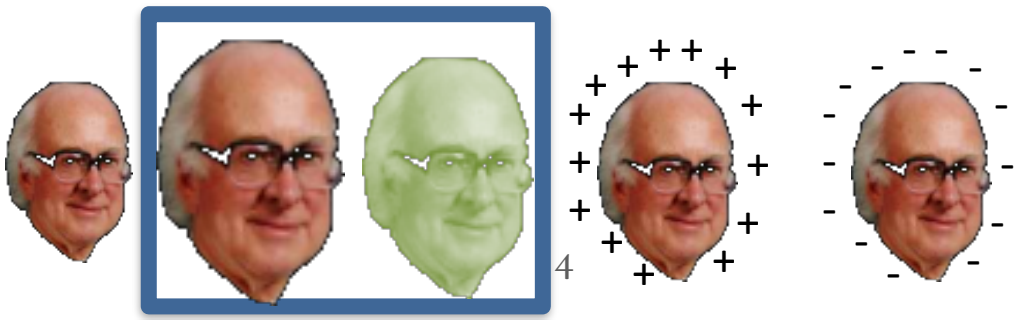
- Run2 is over with more than 150 fb^{-1} of data delivered during 2015-2018.
  - Almost 140 fb^{-1} of that is good for physics.
  - Average μ value for the full Run 2 was ~30.





Beyond the SM

- Standard Model (SM):
  One doublet of Higgs, only one neutral Higgs boson.
- SM needs to be extended:
  ν mass, dark matter…
- Fermions (leptons and quarks) come in three generations, why only one Higgs doublet?
- In many extensions of the SM:
  Prediction of two complex Higgs doublets (2HDM).
- Five physical states: h^0, H^0, A^0, H^+, H^-.



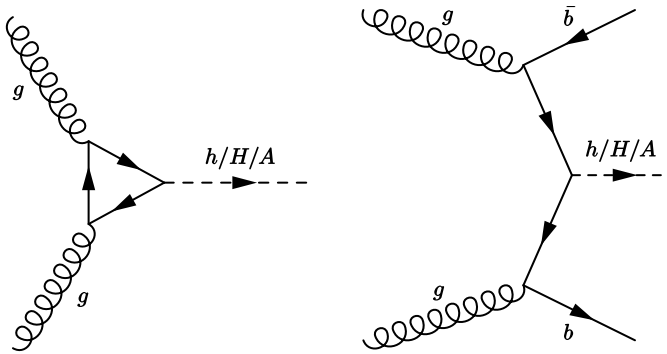
Fermionic Decays

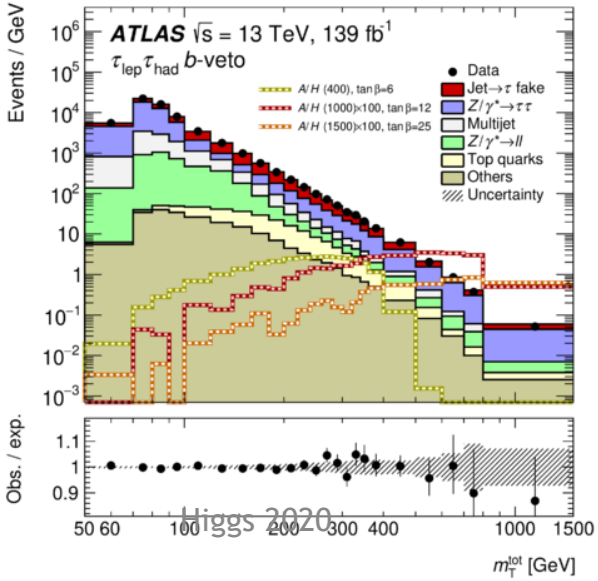
H/A -> ττ

New

- Production: gluon-gluon fusion or b-associated.
- Inspired by MSSM -> τ and b couplings ~tanβ -> interpretation in many MSSM scenarios.
- Analysis:
  - τ_{had}-$\tau_{had/lep}$: split in b-tagged and b-veto categories (τ/lepton trigger) -> probe production modes.
  - Require at least one hadronic τ decay and have angles and invariant masses cuts.
  - Most of the BGs are estimated using MC (with corrections from data). Data-driven techniques are used for processes where the $\tau_{had\text{-}vis}$ charged lepton is misidentified.
  - Discriminating variable:

$$m_T^{\text{tot}} = \sqrt{(p_{\text{T}}^{\tau 1} + p_{\text{T}}^{\tau 2} + E_{\text{T}}^{\text{miss}})^2 - (\boldsymbol{p}_{\text{T}}^{\tau 1} + \boldsymbol{p}_{\text{T}}^{\tau 2} + \boldsymbol{E}_{\text{T}}^{\text{miss}})^2}$$

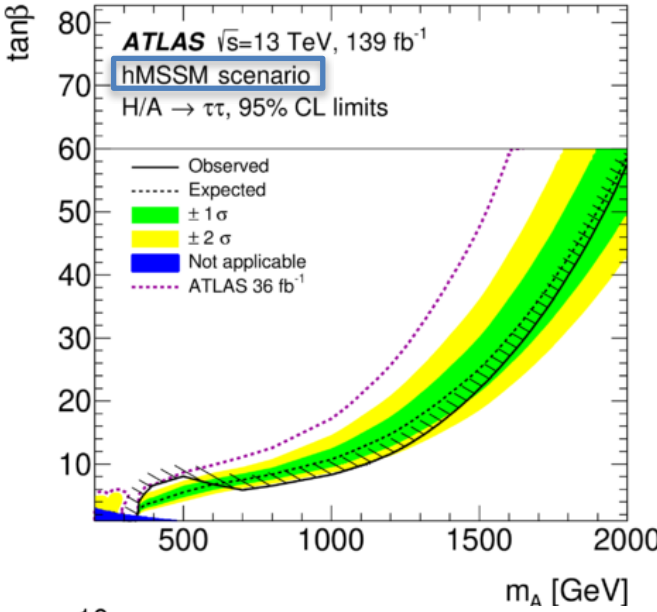


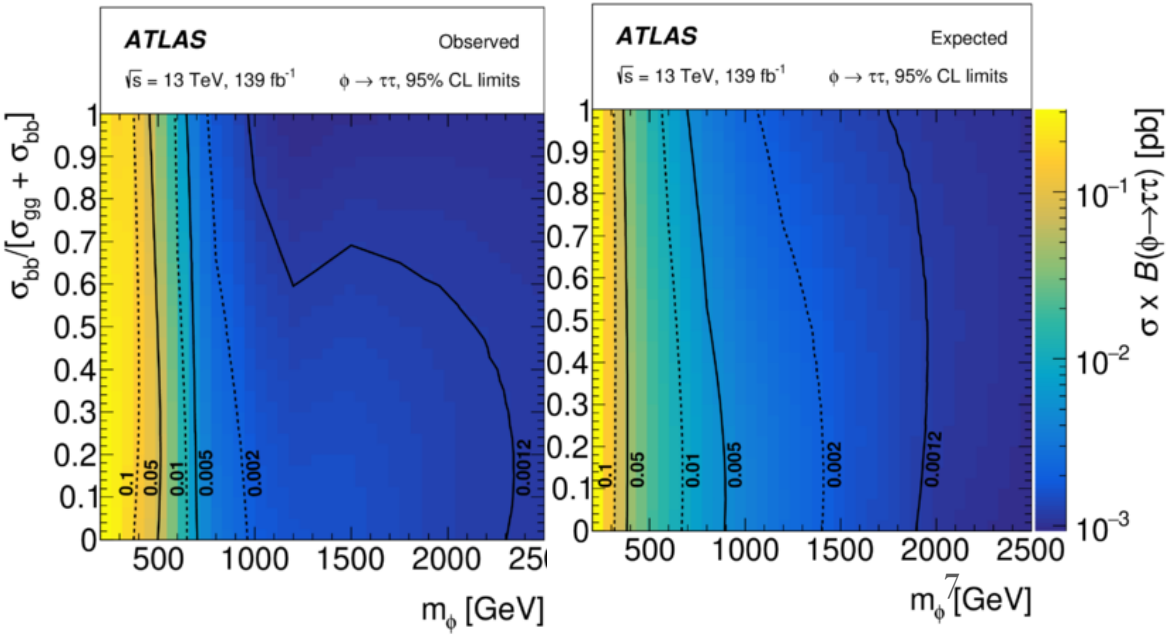


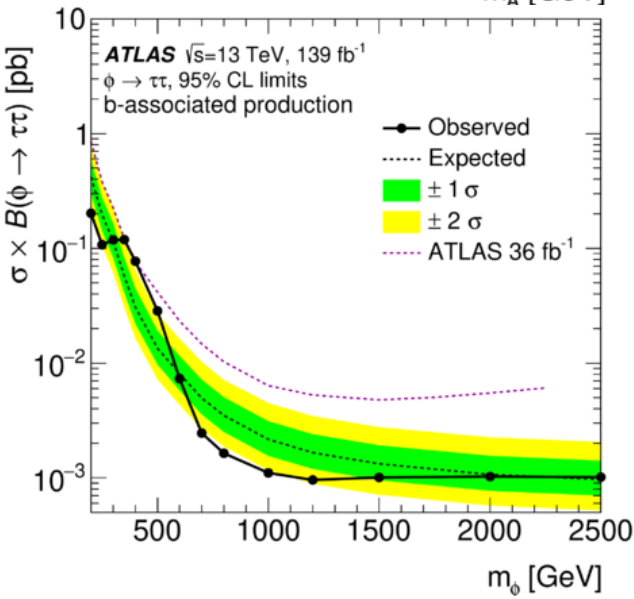
H/A -> ττ

New

- The search is performed over the mass range 0.2–2.5 TeV.
- Upper limits on XS*BR are set at the 95% CLs:
  - 240–1.2 fb for gluon–gluon fusion.
  - 230–1.0 fb for b-associated.
- Lowest local p0 is 0.014 (2.2σ) at m = 400 GeV.

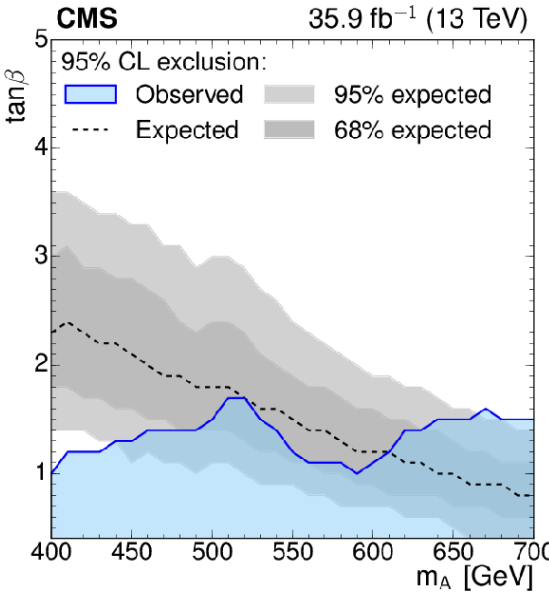


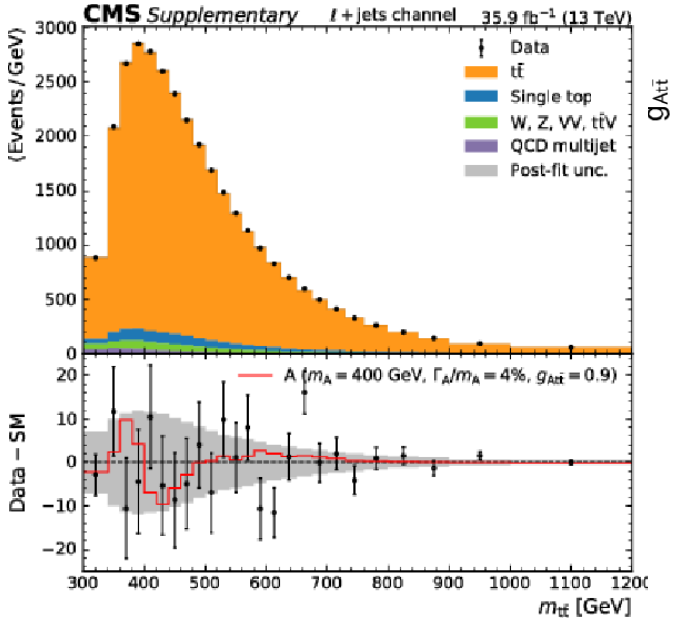


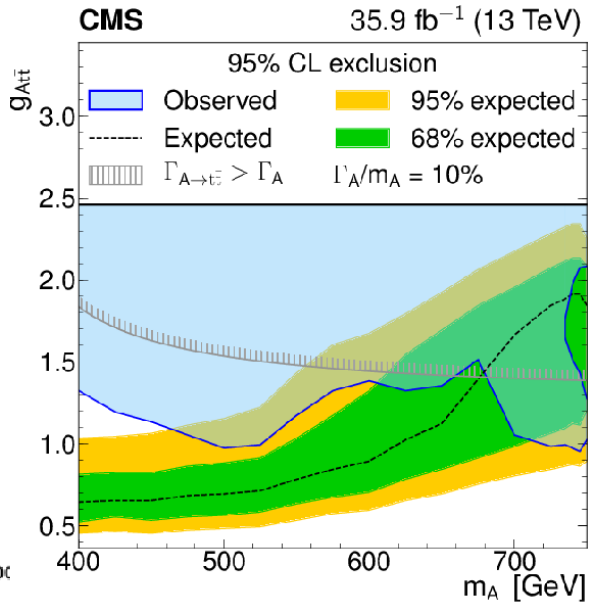


H/A -> tt̄

- The search is performed over the mass range 400-750 GeV with total relative width of 0.5-25%.
- Event selections:
  - Basic semi/di-leptonic ttbar selections.
  - Special spin-sensitive variables.
- The interference with the SM ttbar BG is taken into account.
- A small peak-dip structure is observed at at the lowest masses tested with 1.9σ global significance.

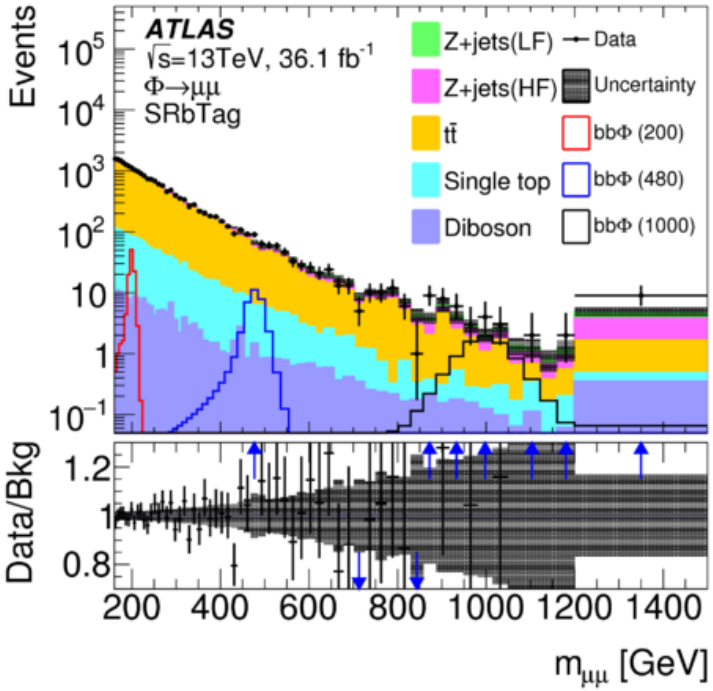


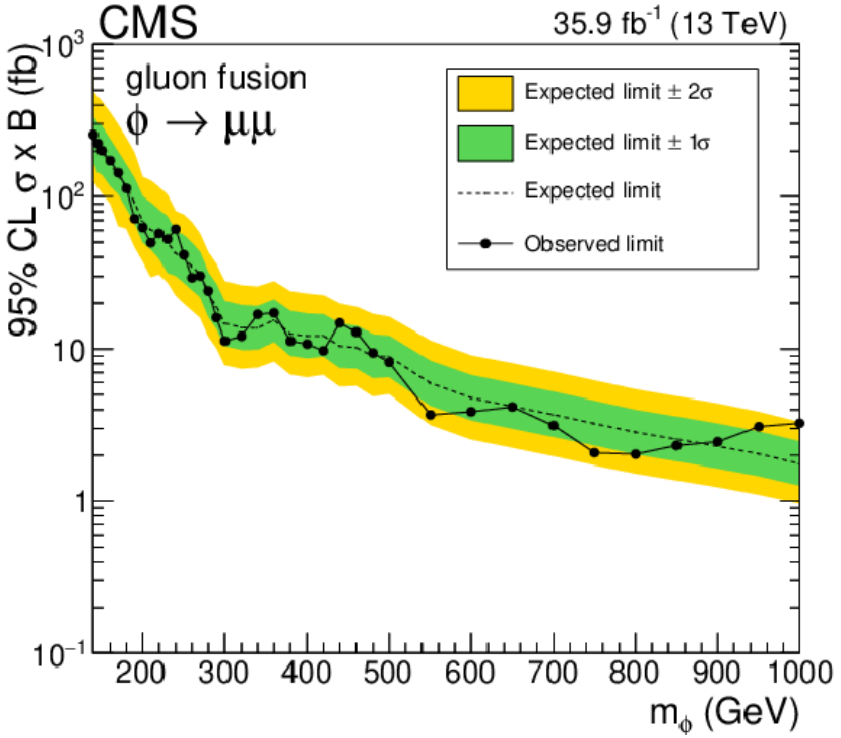




H -> μμ

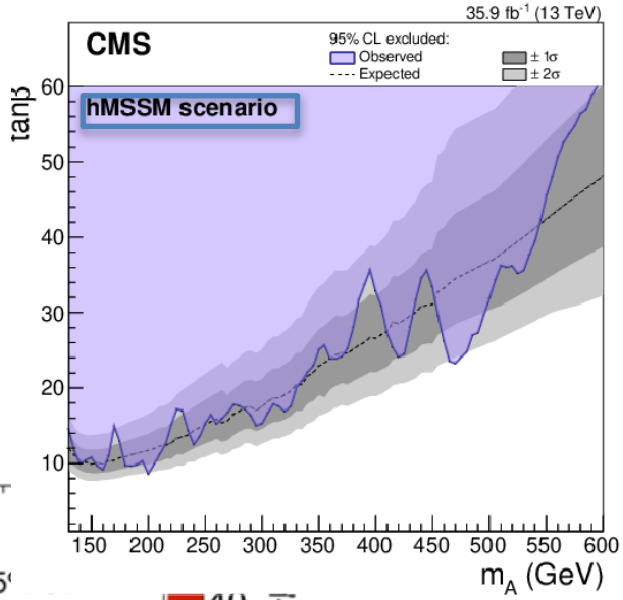
- Production: gluon-gluon fusion or b-associated.
- Require at least 2 opposite charged muons and additional b-tagged jets for the different regions.
- BGs are
  - ATLAS: estimated by using MC (with corrections from data).
  - CMS: modelled using functional forms.

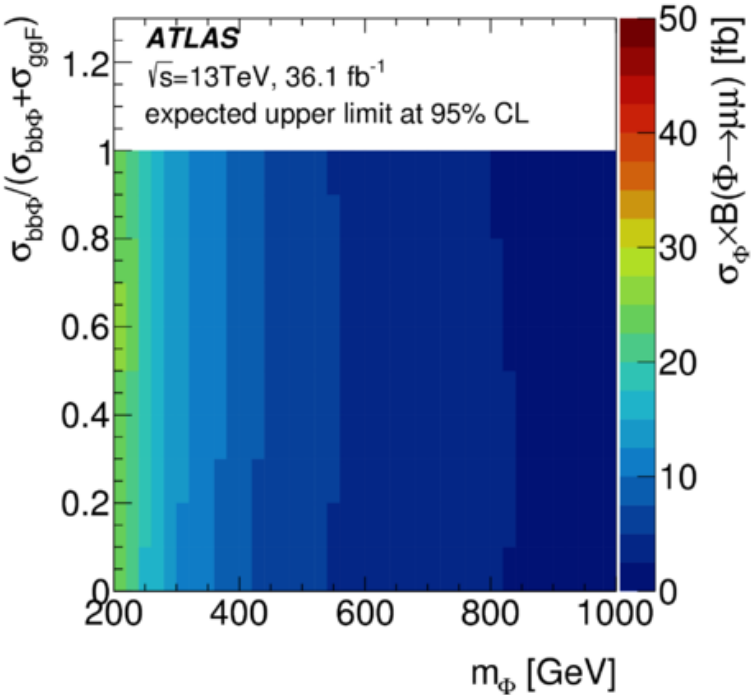


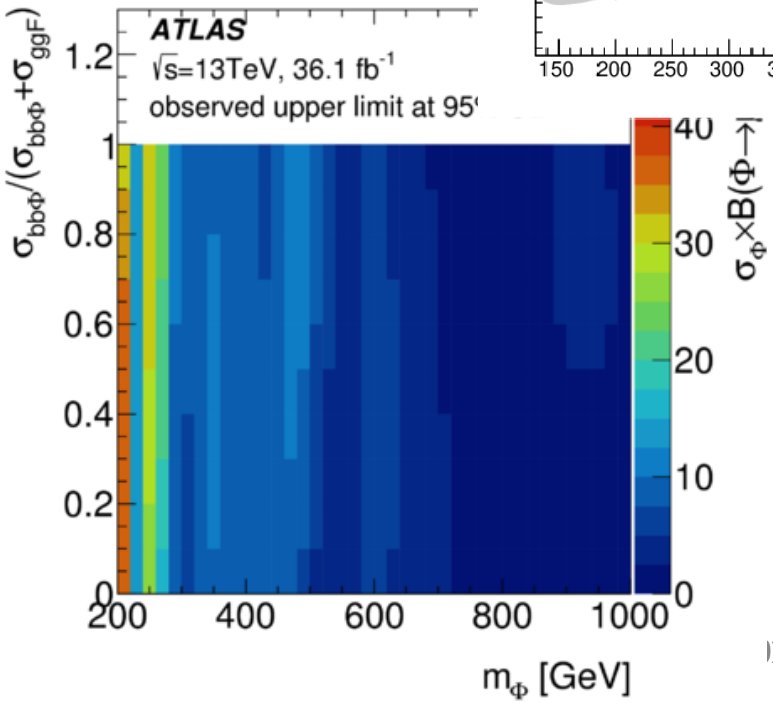


H -> μμ

- The search is performed over the mass range:
  - ATLAS: 200 GeV- 1 TeV.
  - CMS: 130 GeV - 1 TeV.

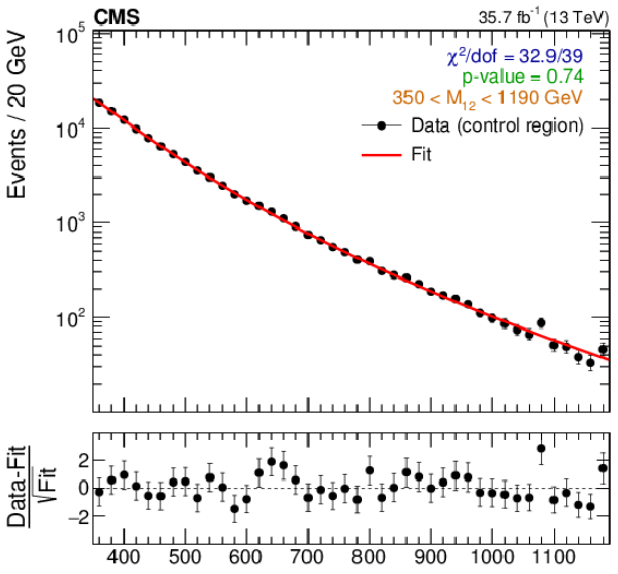


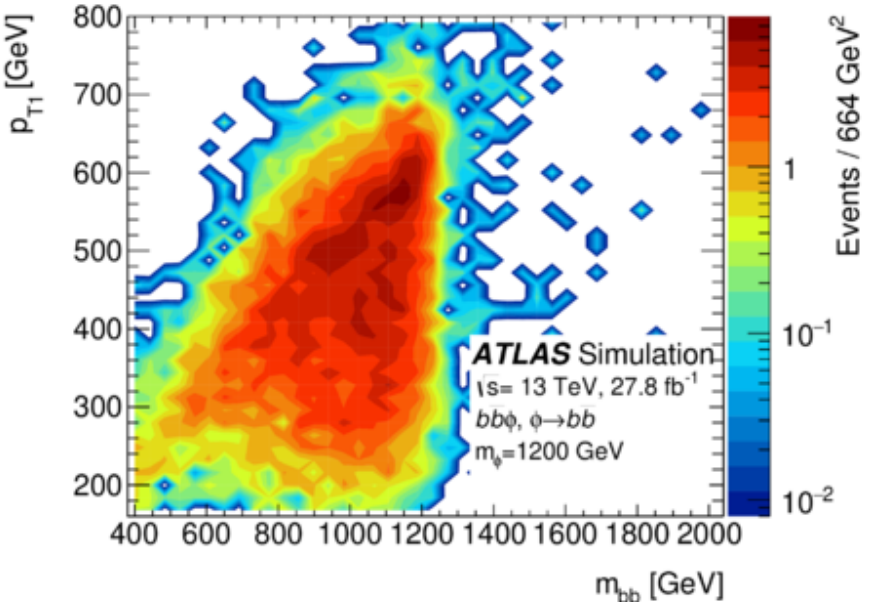


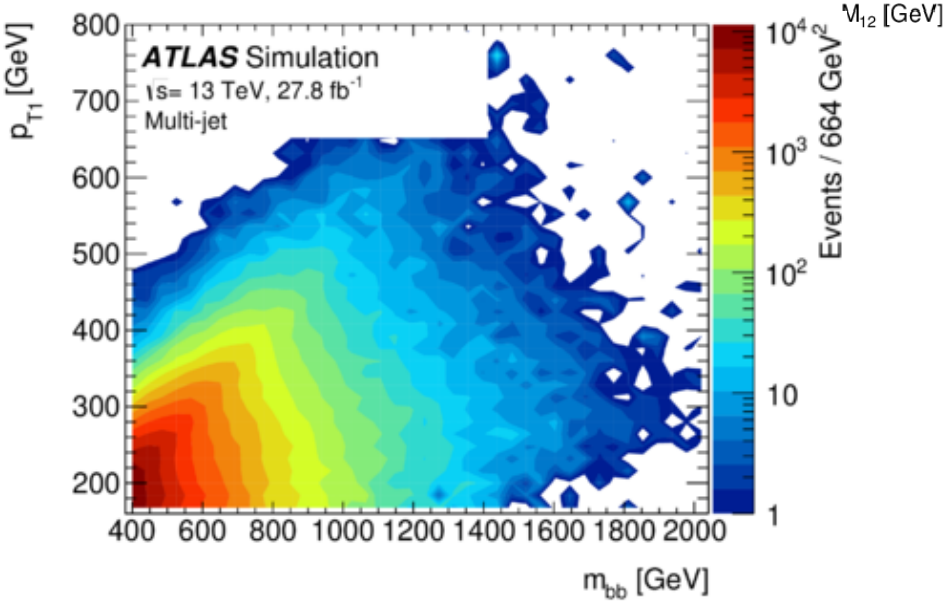


H/A -> bb̄

- Production: b-associated.
- Require at least 3 b-tagged jets and different angular selections.
- Different multiplicities of (b-tagged) jets are used for the different regions.
- BGs estimation is data driven.

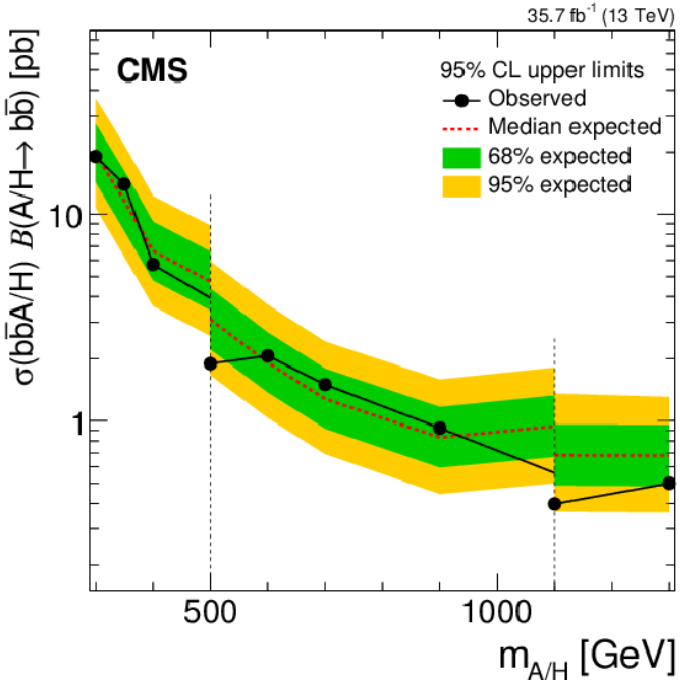


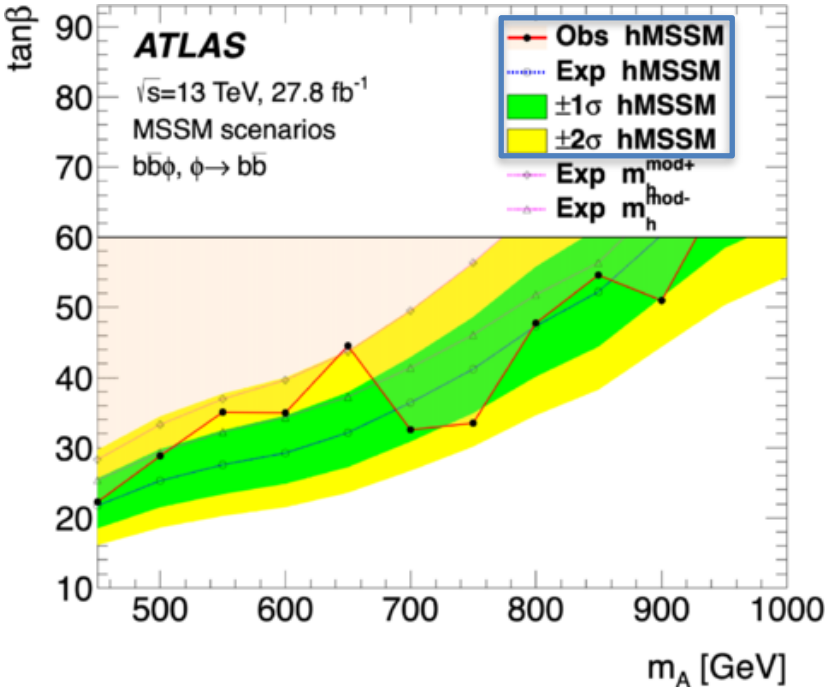




H/A -> $b\bar{b}$

- The search is performed over the mass range 300 (450) GeV – 1.3 (1.4) TeV for CMS (ATLAS).
- Upper limits on XS*BR are set at the 95% CLs:
  - 0.6–4.0 pb for ATLAS.
  - 0.4-20 pb for CMS.





Summary

- Amazing collection of results using 13 TeV dataset:
  - Most of them are only with 2015-2016 data….
- Unfortunately, no significant deviation from the SM prediction has been observed yet.
- Many more exciting results to come using the full run2 dataset.

Bibliography

- **H-> ττ:**

  ATLAS: Phys. Rev. Lett. 125 (2020) 051801.

- **H-> tt:**

  CMS: JHEP 04 (2020) 171.

- **H-> μμ:**

  ATLAS: JHEP 07 (2019) 117.

  CMS: Phys. Lett. B 798 (2019) 134992.

- **H->bb:**

  ATLAS: Phys. Rev. D 102 (2020) 032004.

  CMS: JHEP 08 (2018) 113.

- Further reference: **H-> μτ/eτ:**

  CMS: JHEP 03 (2020) 103.