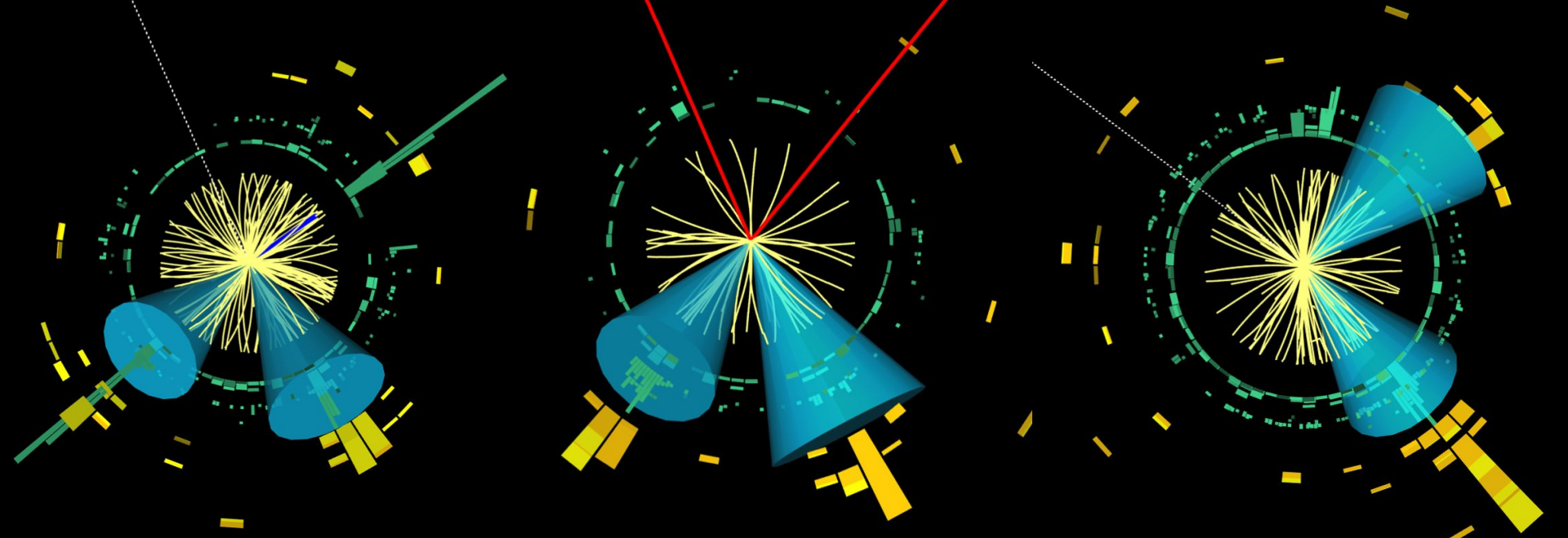


Higgs Production at the LHC

Matt Klein, Southern Methodist University

2024 May 20

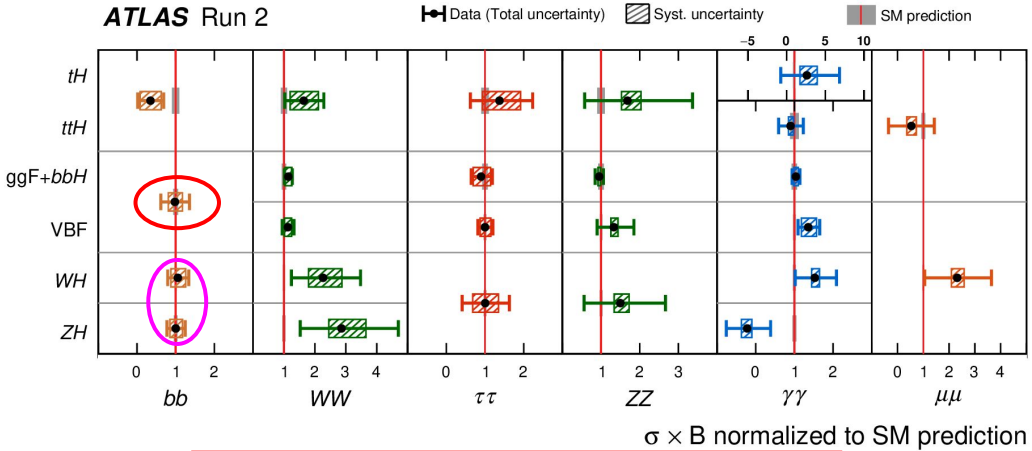
SMU

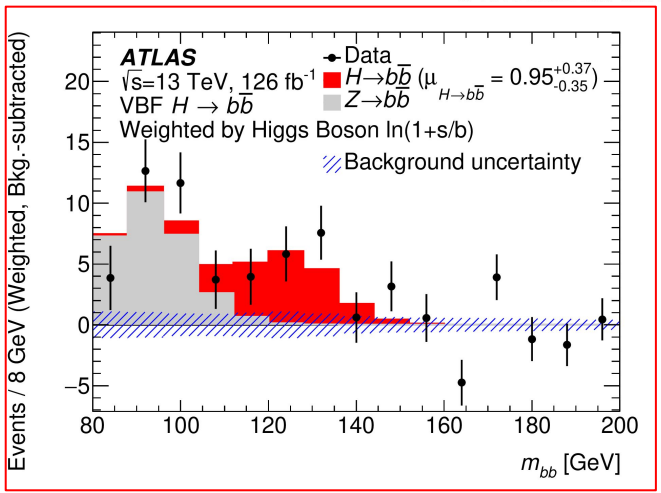
ATLAS EXPERIMENT

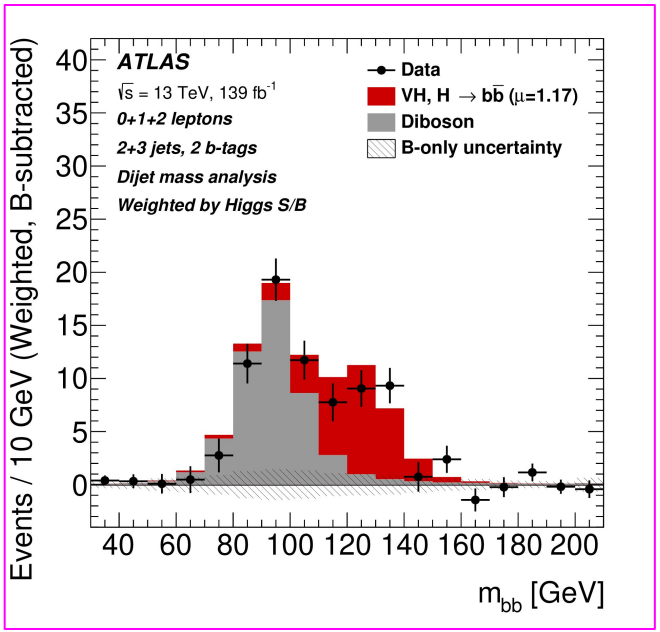
Overview

- Individual Measurements
  - Production Mode x Decay
  - Semi-differential: STXS
  - Fully differential
- Interpretations
  - Combined x-sections
  - Combined STXS
  - Kappa-framework
- Properties
  - Mass
  - Width

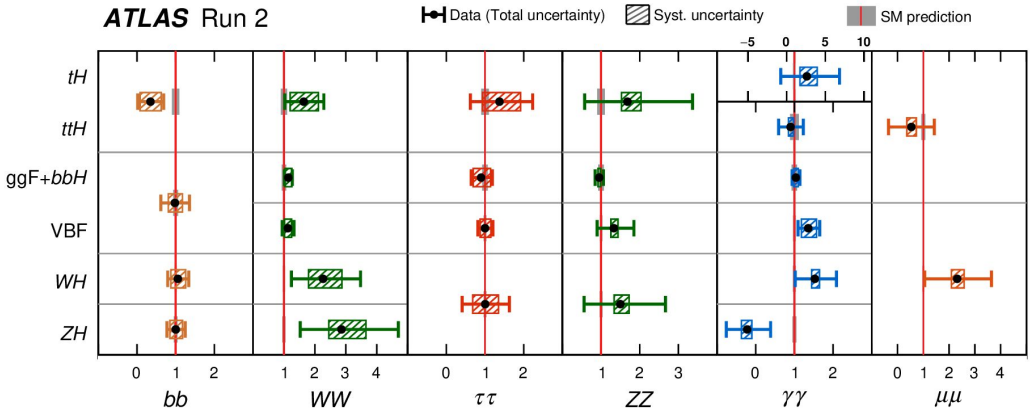
Measurements: Cross-section (1)

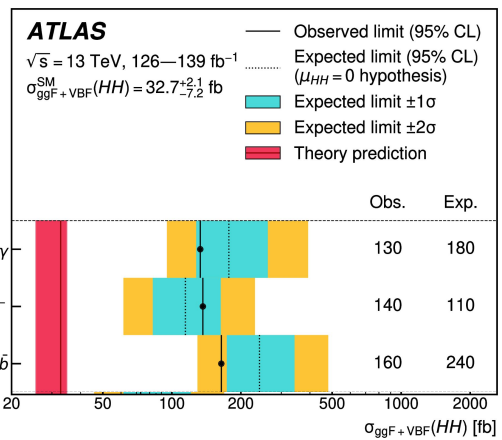


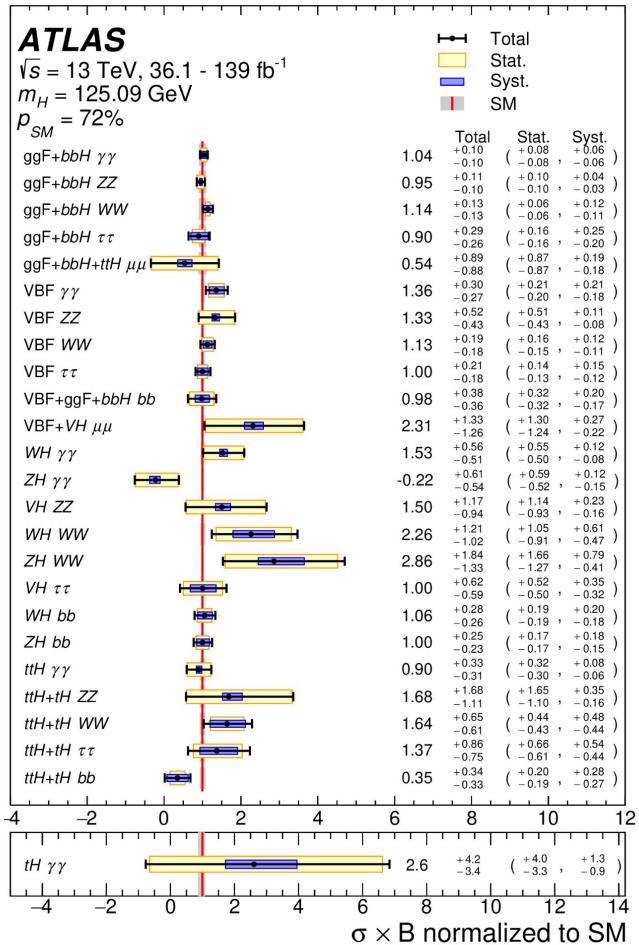




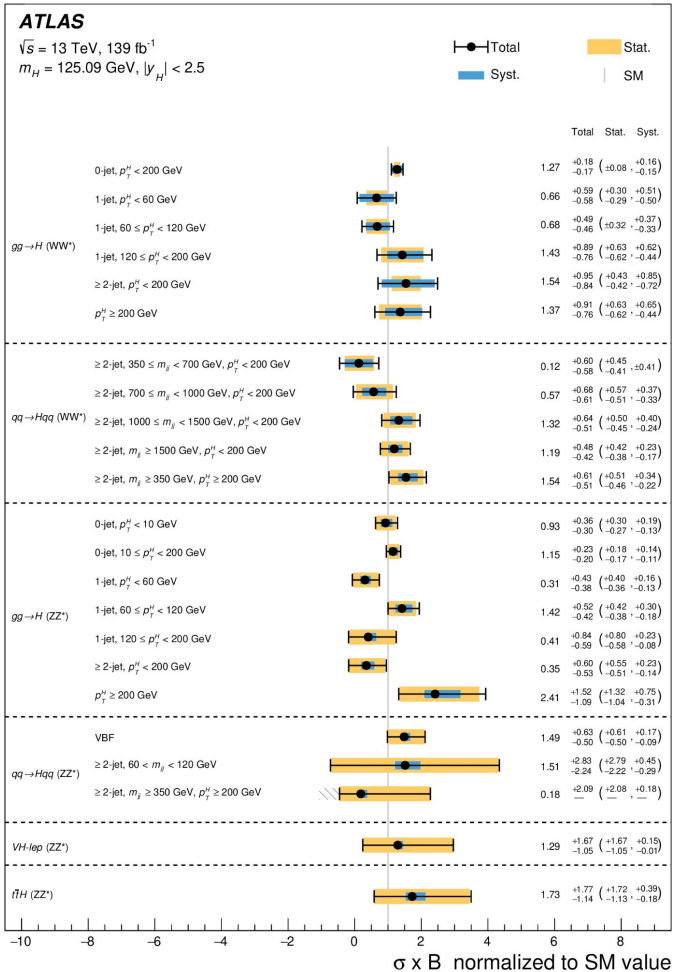
Measurements: Cross-section (2)

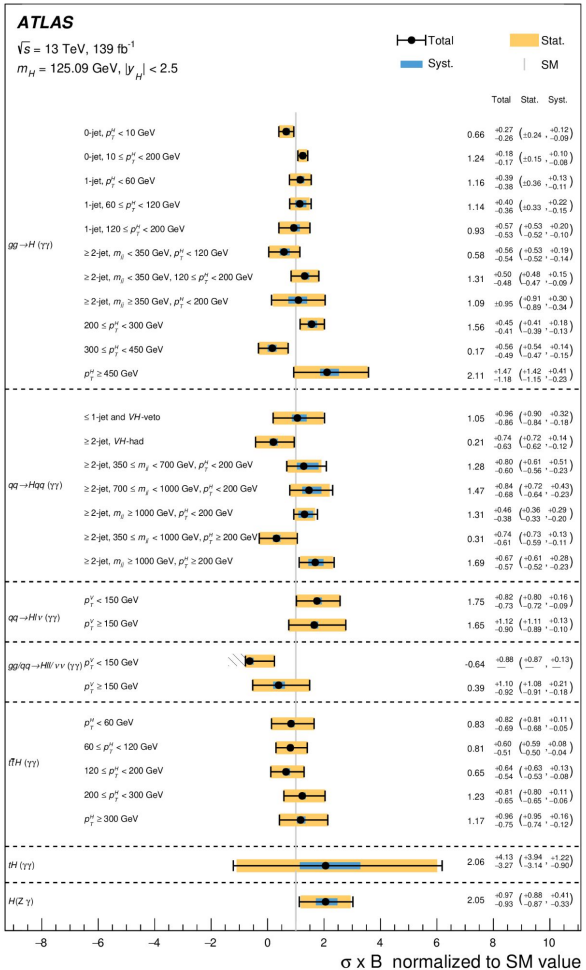


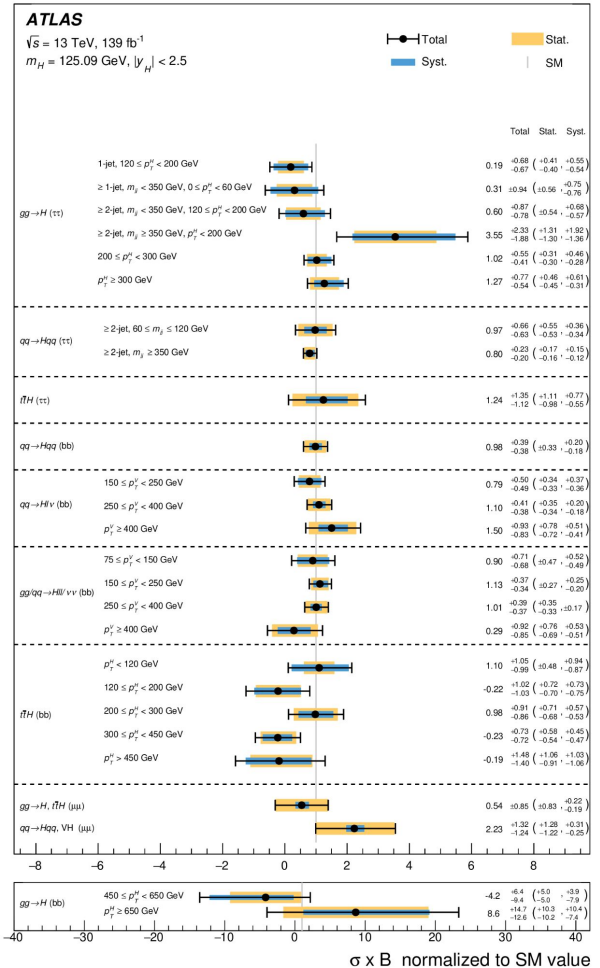




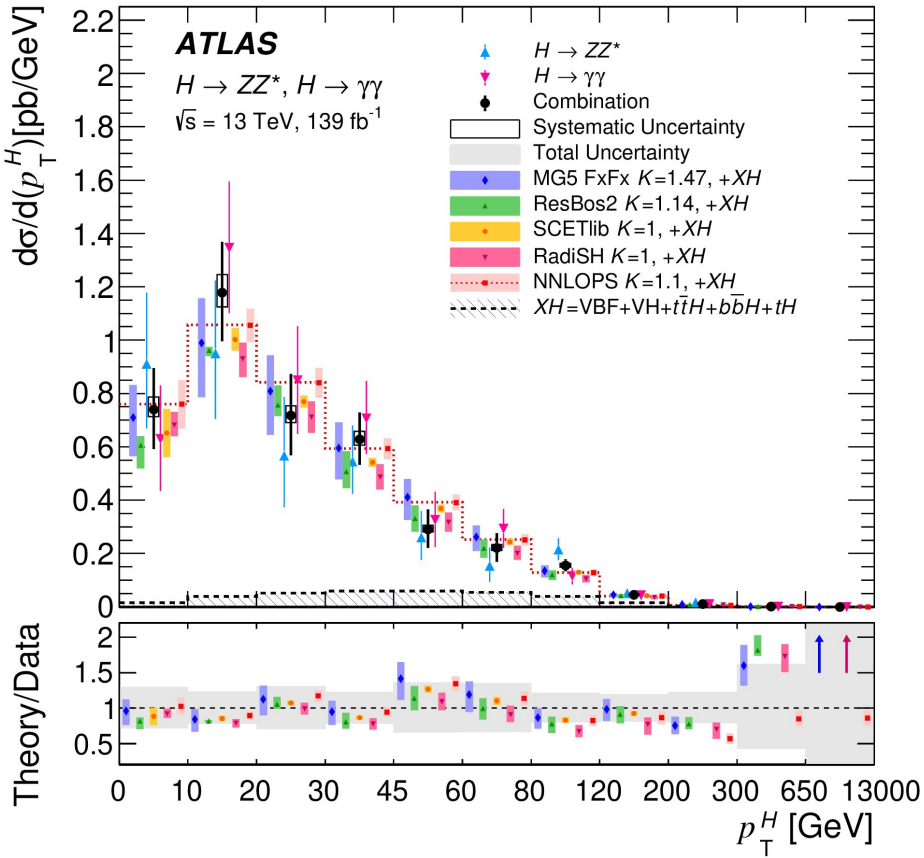
Measurements: STXS

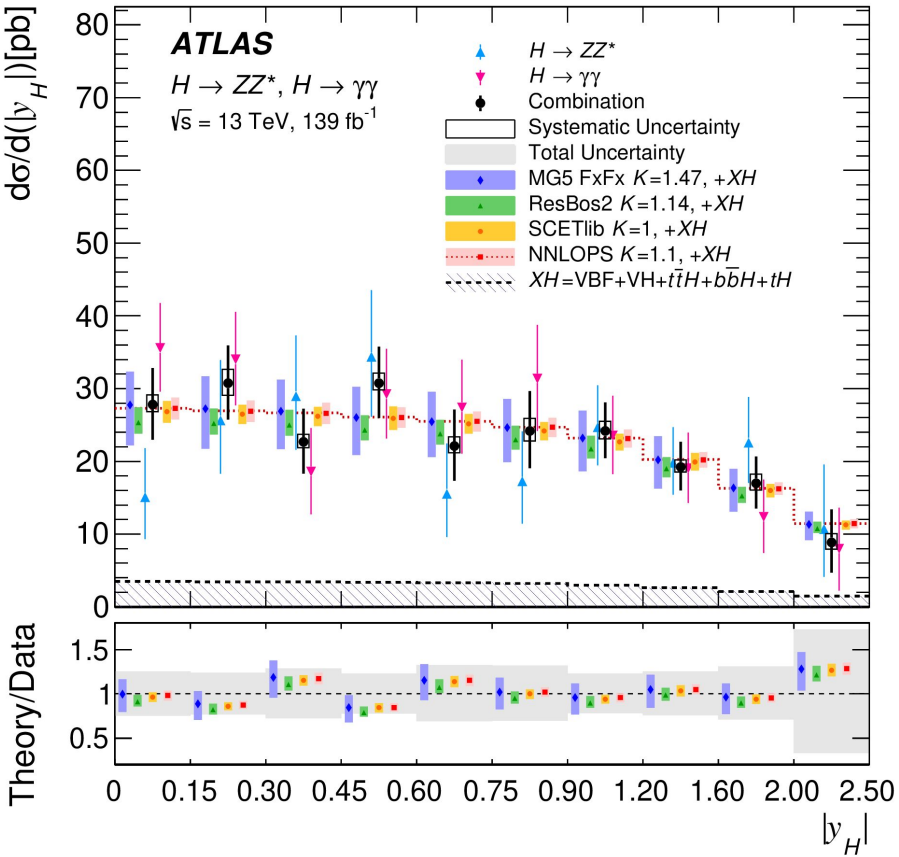




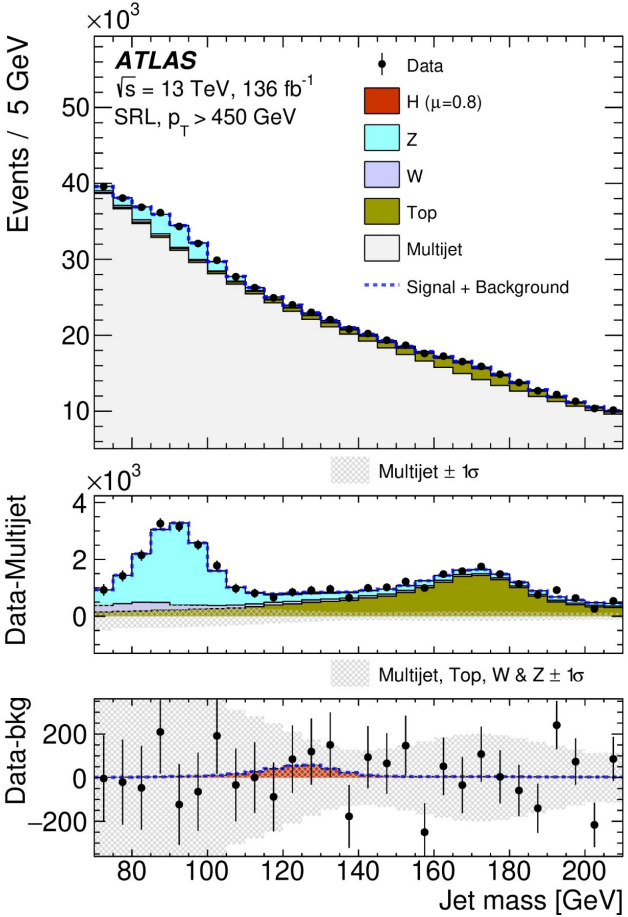


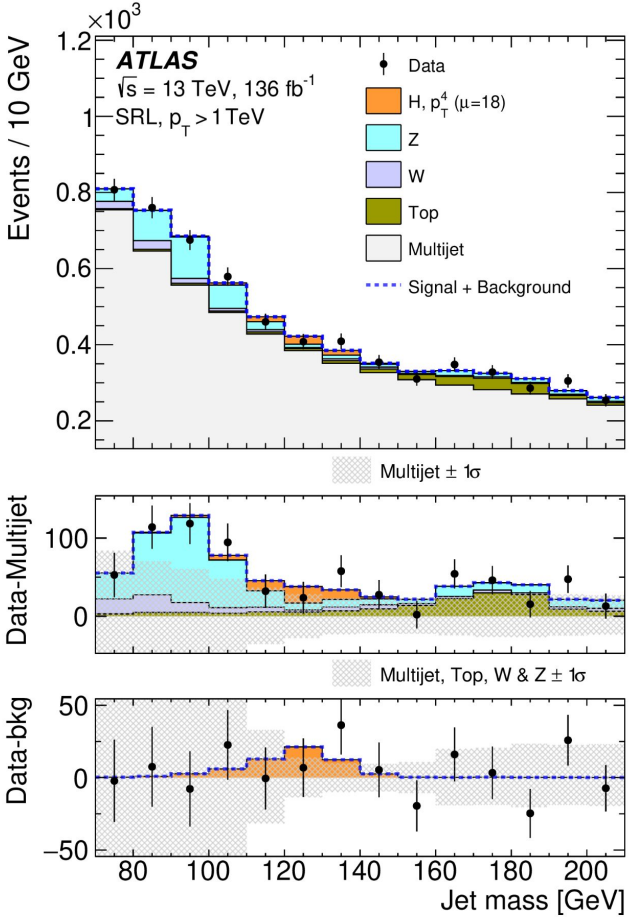
Measurements: Differential

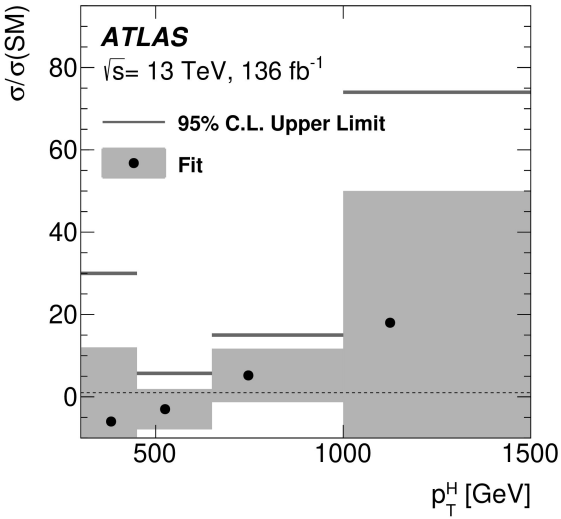




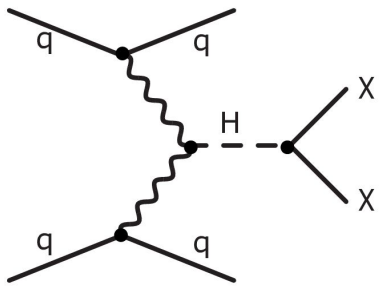
Measurements: High p_T

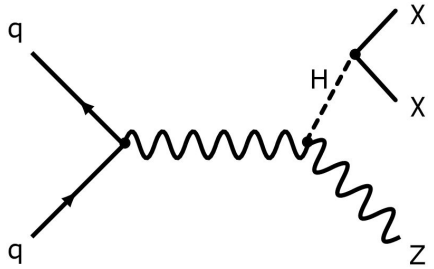




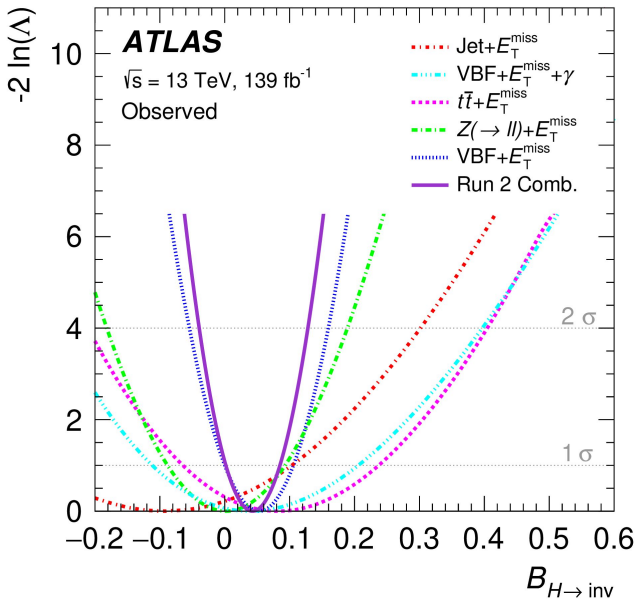


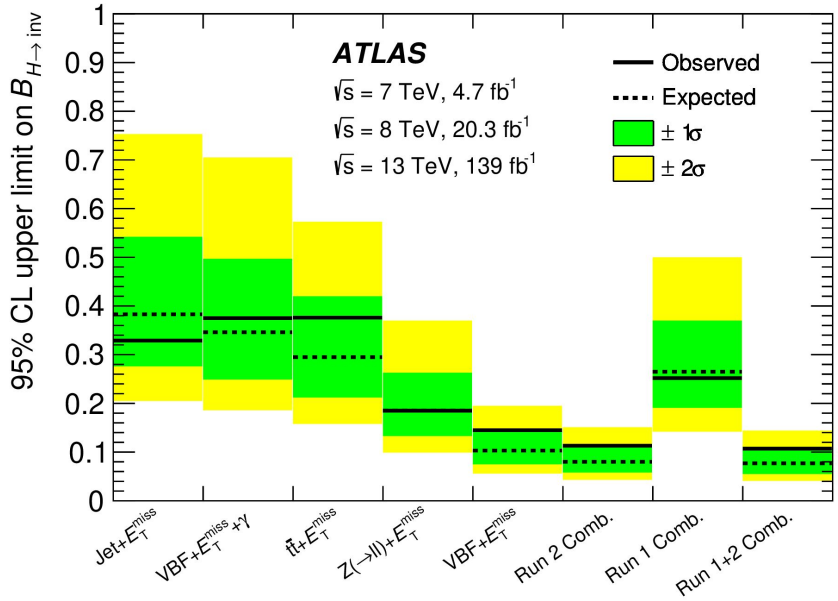
Measurements: BSM Decays (Invisible)



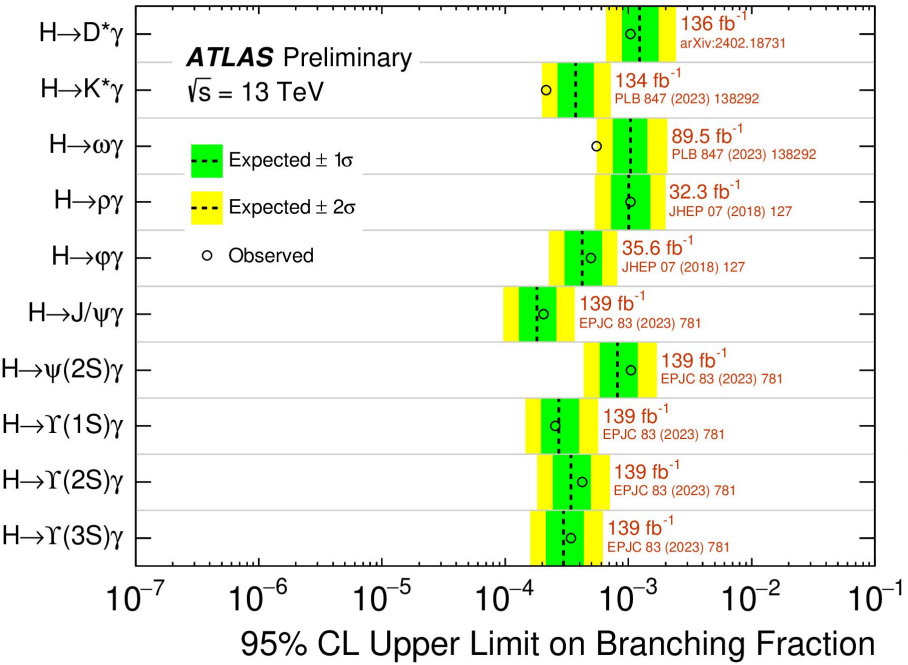


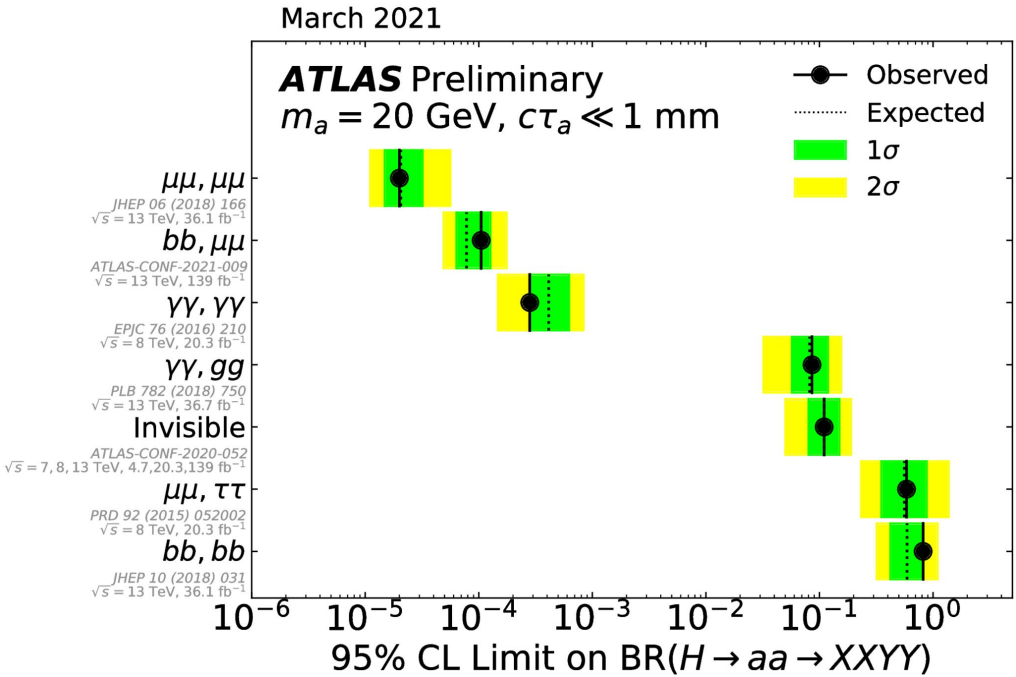
Only showing H→inv





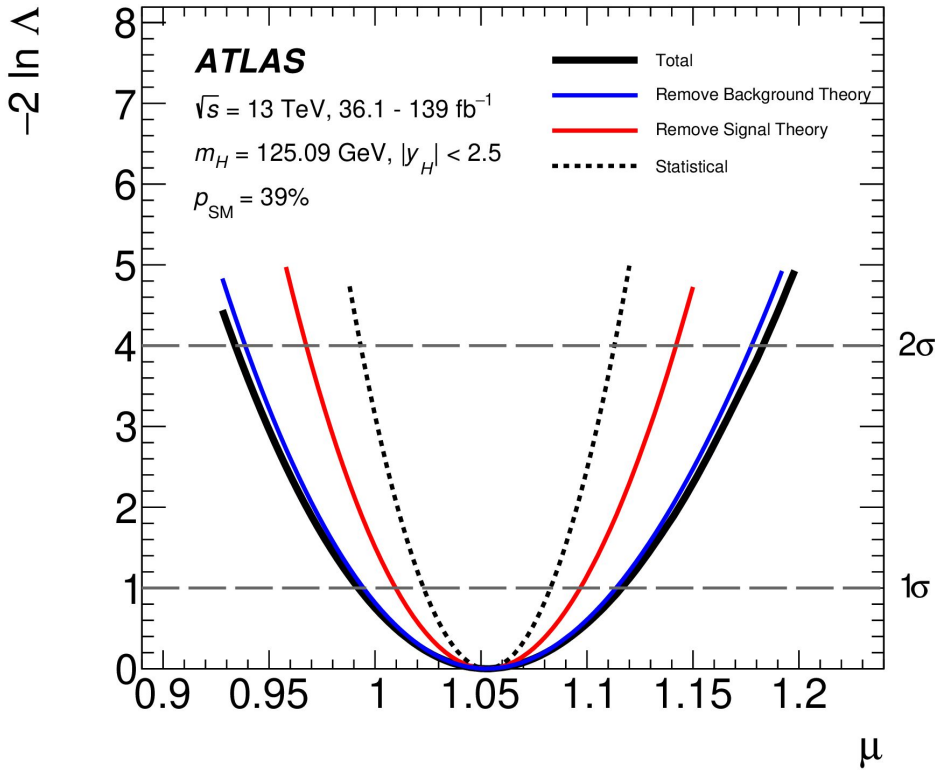
Measurements: BSM Decays (Other)



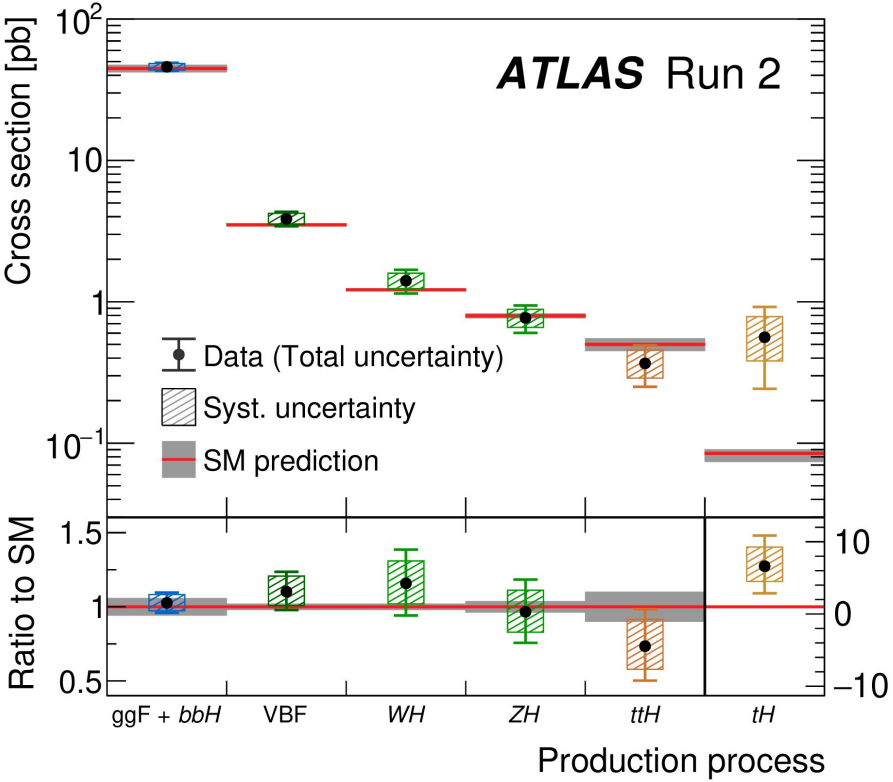


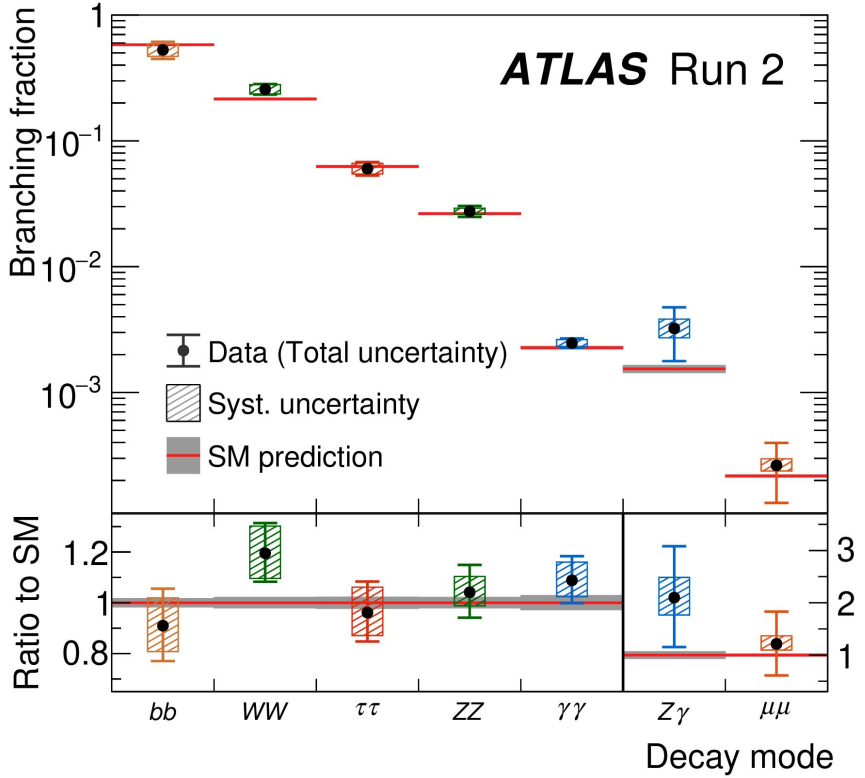
Interpretations: Inclusive Cross-section

$$\mu = 1.05 \pm 0.06 = 1.05 \pm 0.03\,(\text{stat.}) \pm 0.03\,(\text{exp.}) \pm 0.04\,(\text{sig. th.}) \pm 0.02\,(\text{bkg. th.})$$

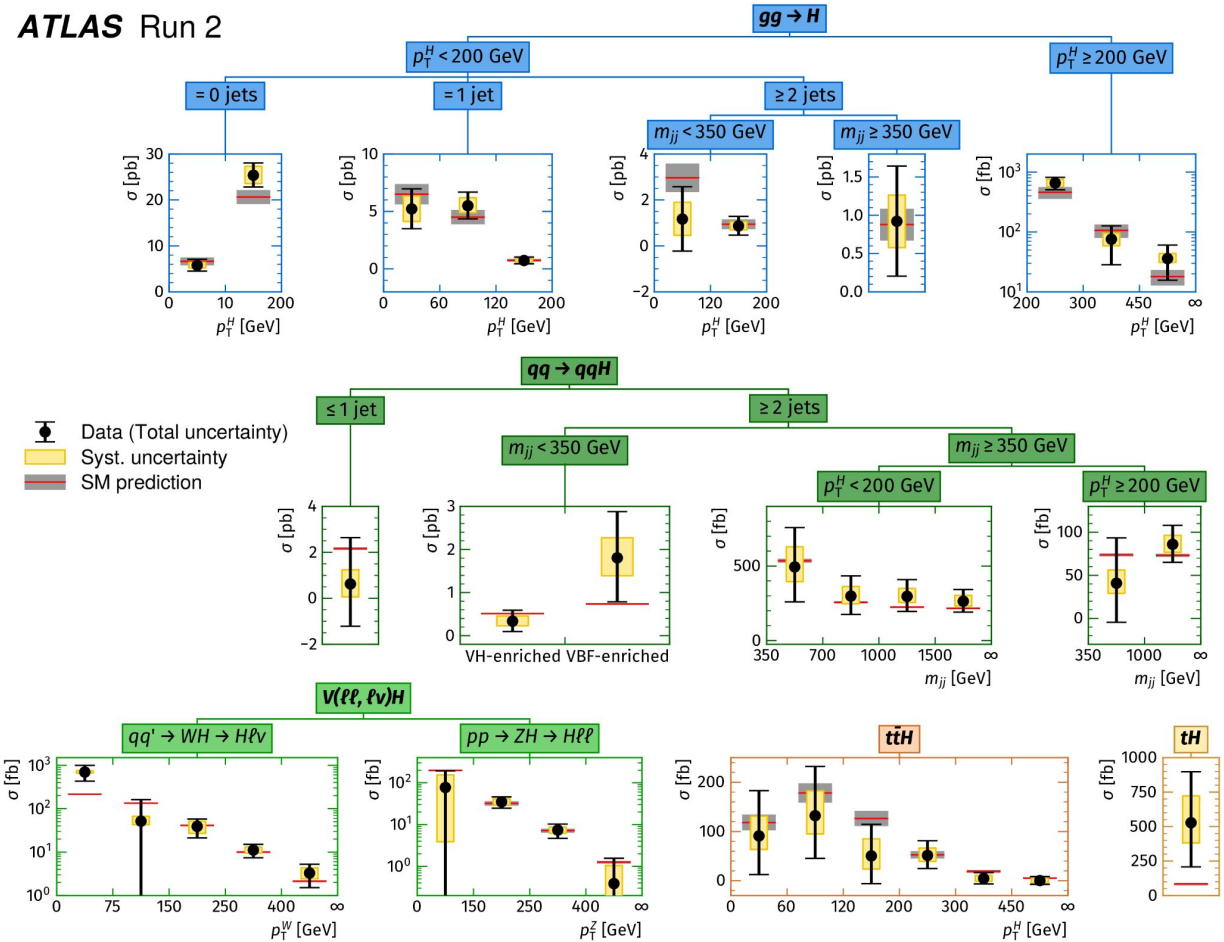


Interpretations: Production and Decays





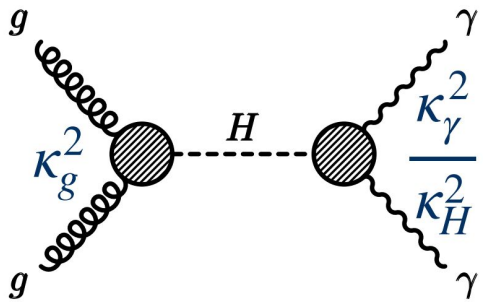
Interpretations: STXS



Interpretations: Kappa-Framework (1)

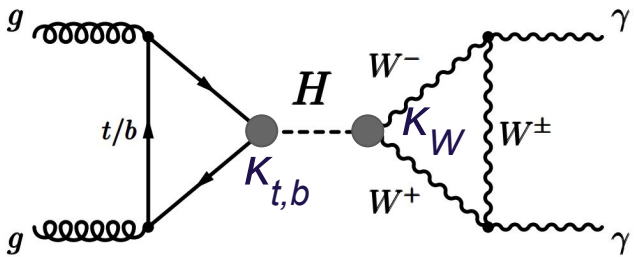
- Assign modifiers (κ_i) to couplings to SM particles
- Two choices for effective couplings (e.g. Hγγ)

Use effective Hγγ coupling in model



or

Use SM (e.g.κ_t) in model

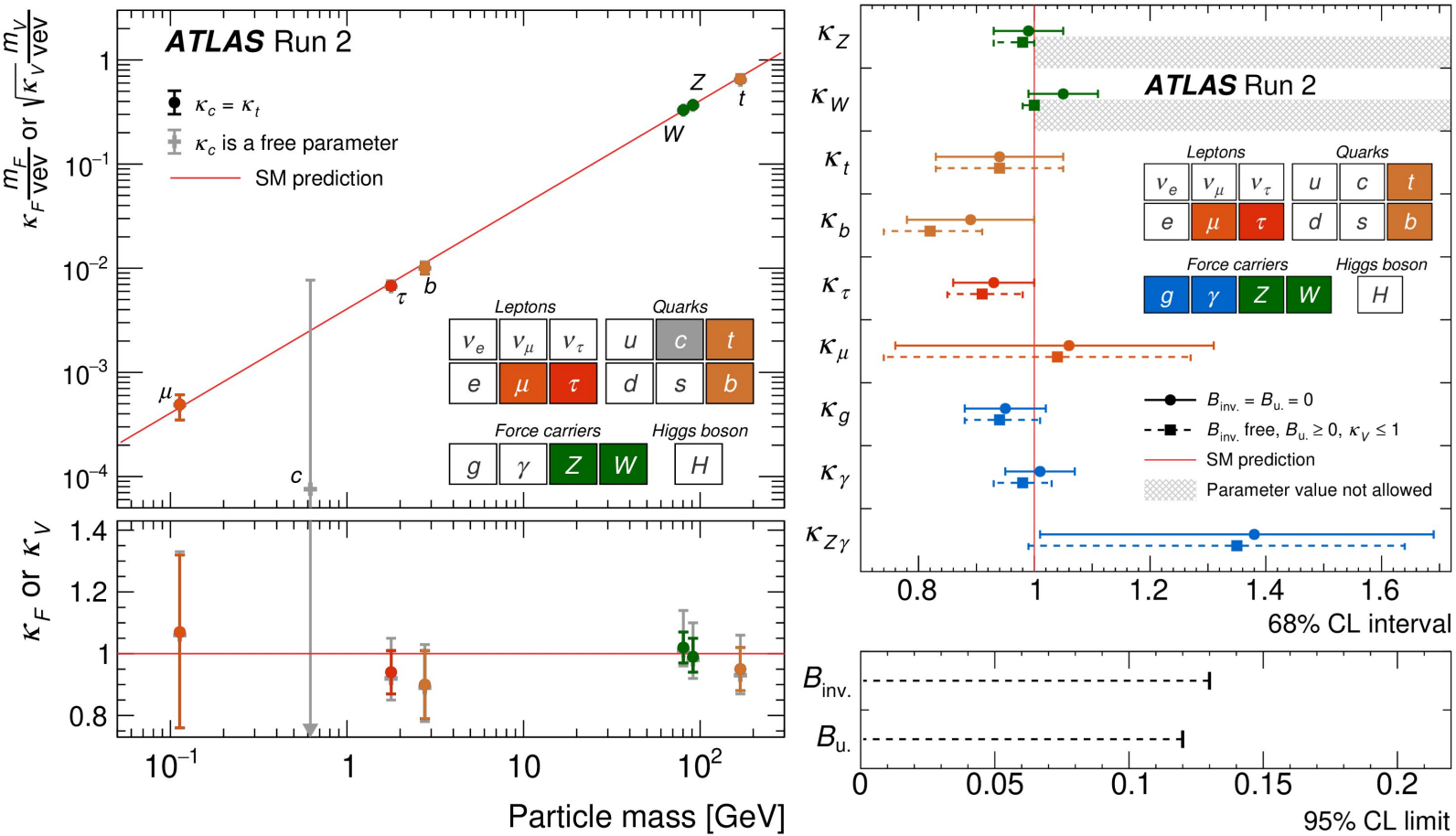


+…

- Higgs width also affected by addition of invisible and undetected decays

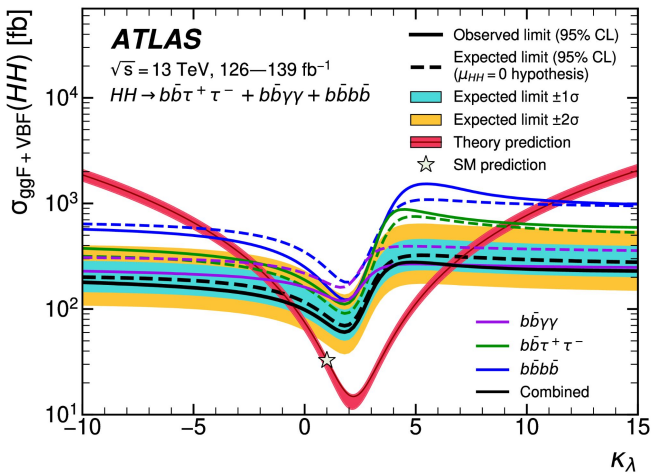
$$\kappa_H^2(\boldsymbol{\kappa}, B_{\text{inv}}, B_{\text{undet}}) = \frac{\sum_j B_j^{\text{SM}} \kappa_j^2}{(1 - B_{\text{inv}} - B_{\text{undet}})}$$

Interpretations: Kappa-Framework (2)

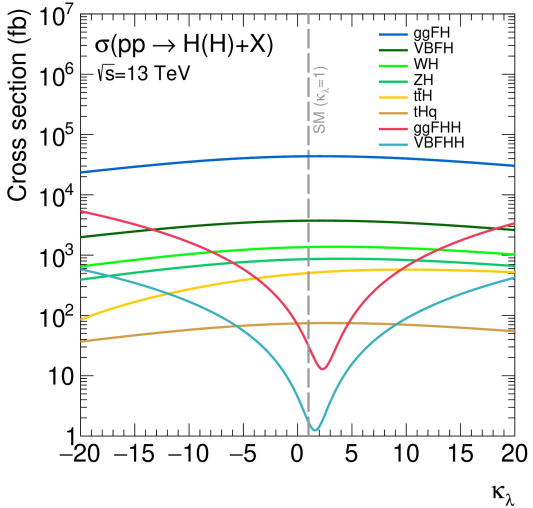


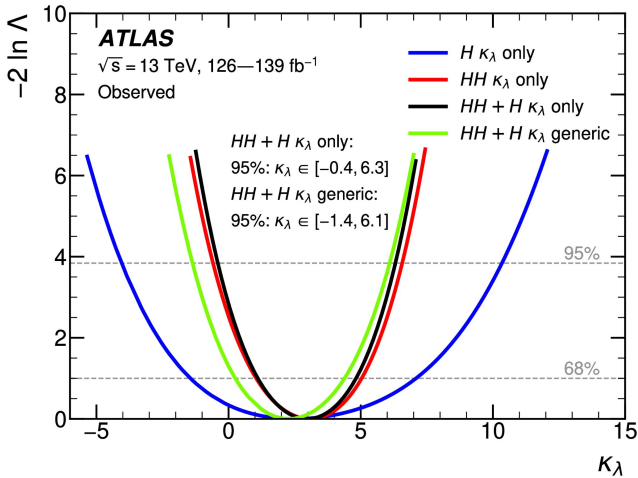
Interpretations: Higgs Self-Coupling

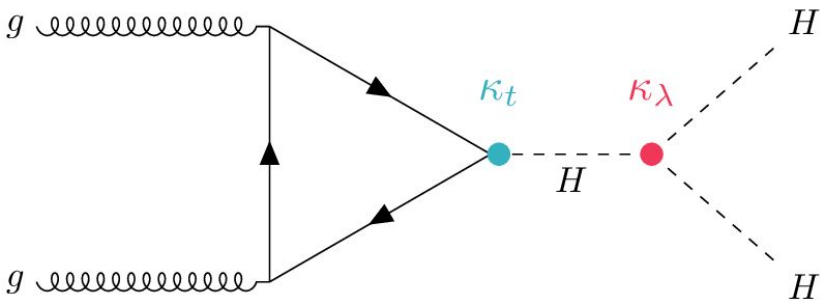
Direct HH measurement

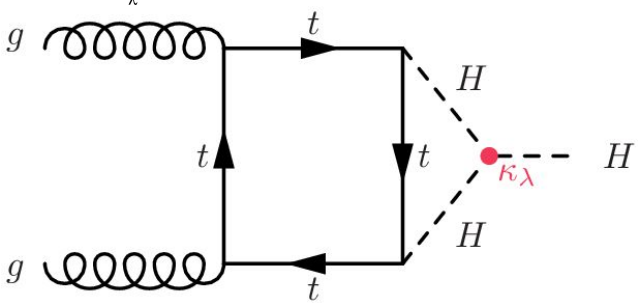


Combined with single H measurements



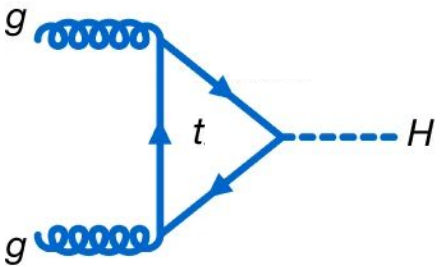


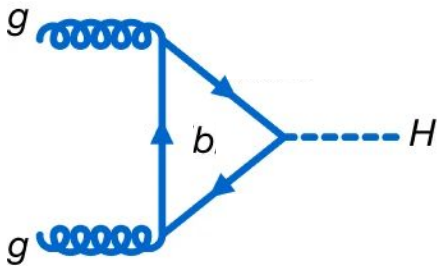


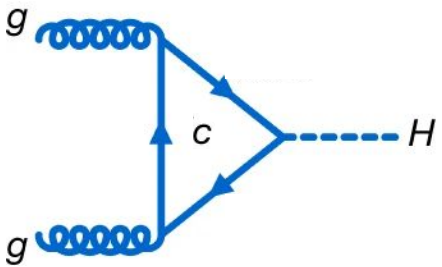


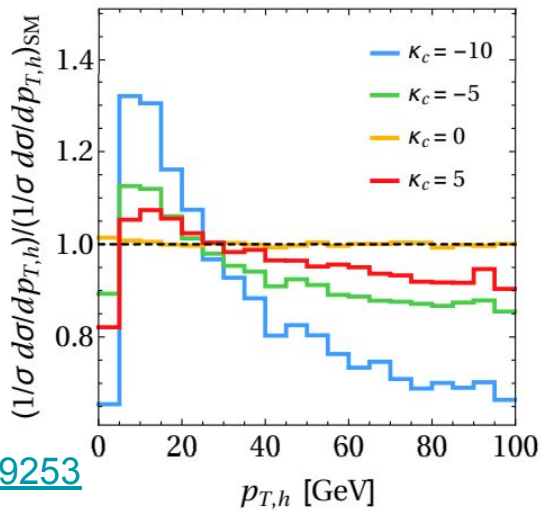
Interpretations: Differential

Can set κ_c constraints using differential p_T^H measurement

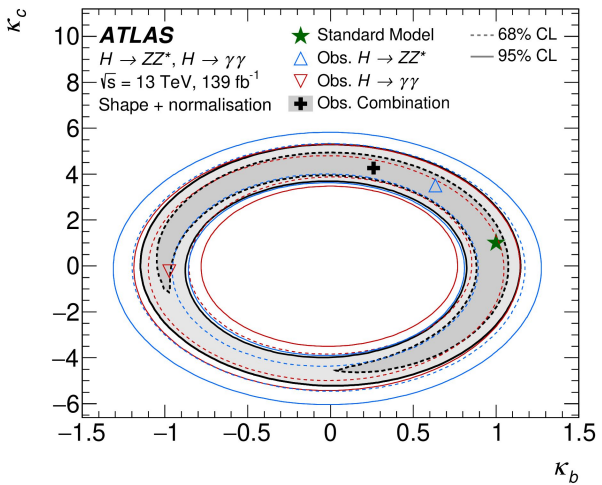


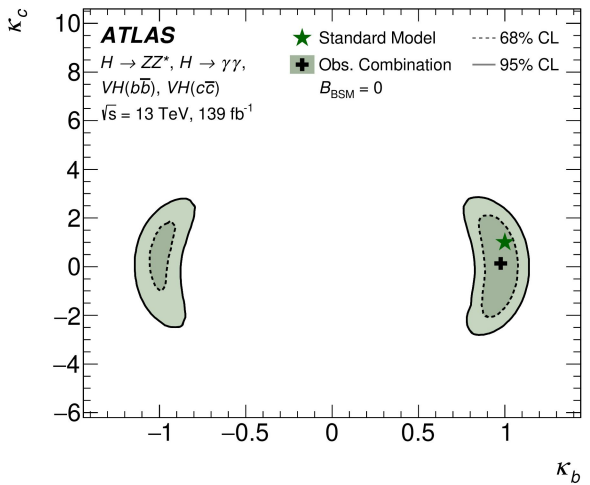




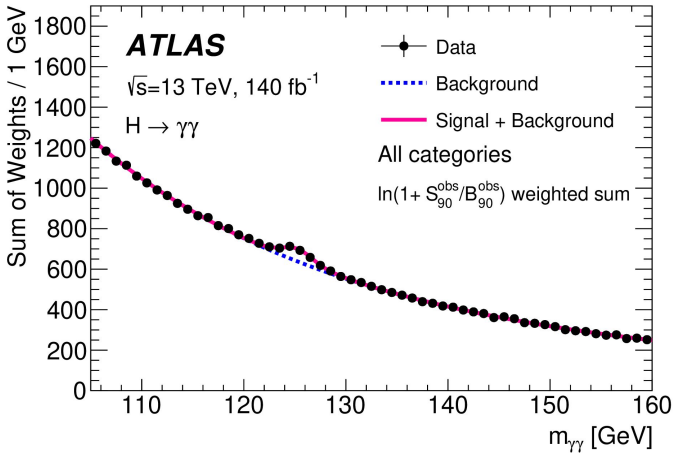


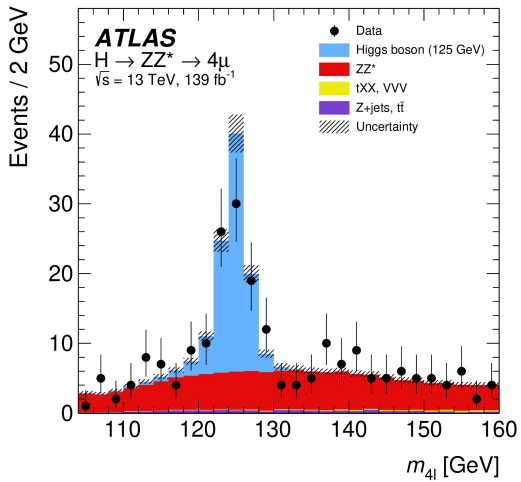
[1606.09253](1606.09253)

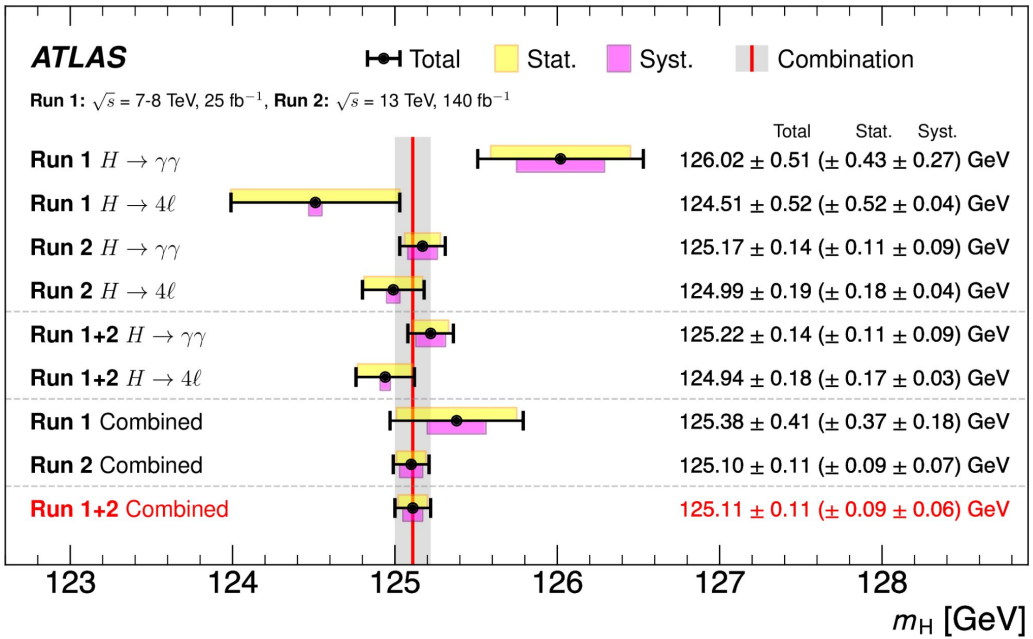




Properties: Higgs Boson Mass



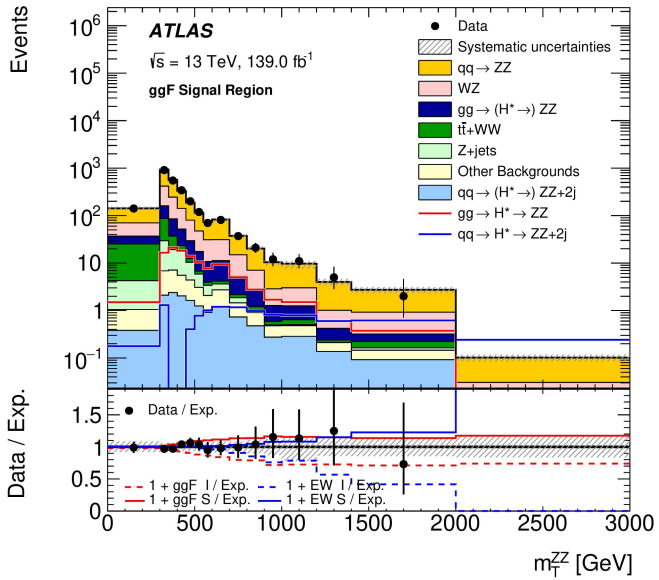


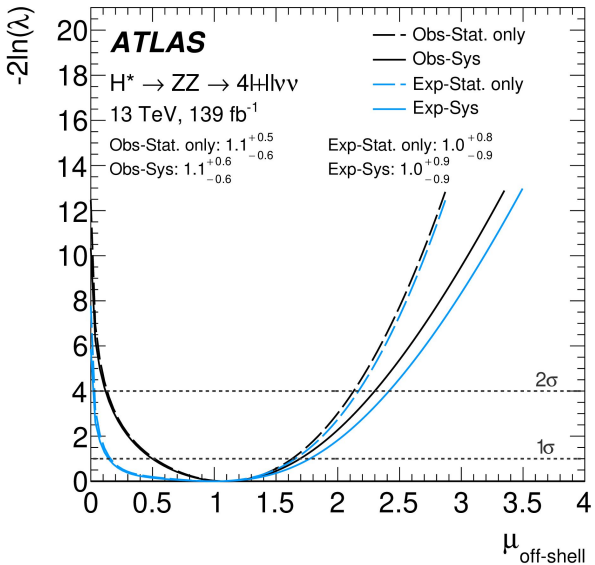


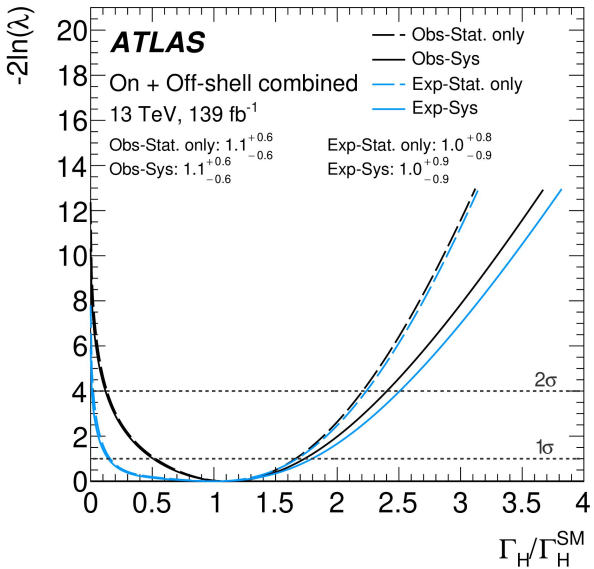
Properties: Higgs Boson Width

Indirect, based on measurement of off-shell production

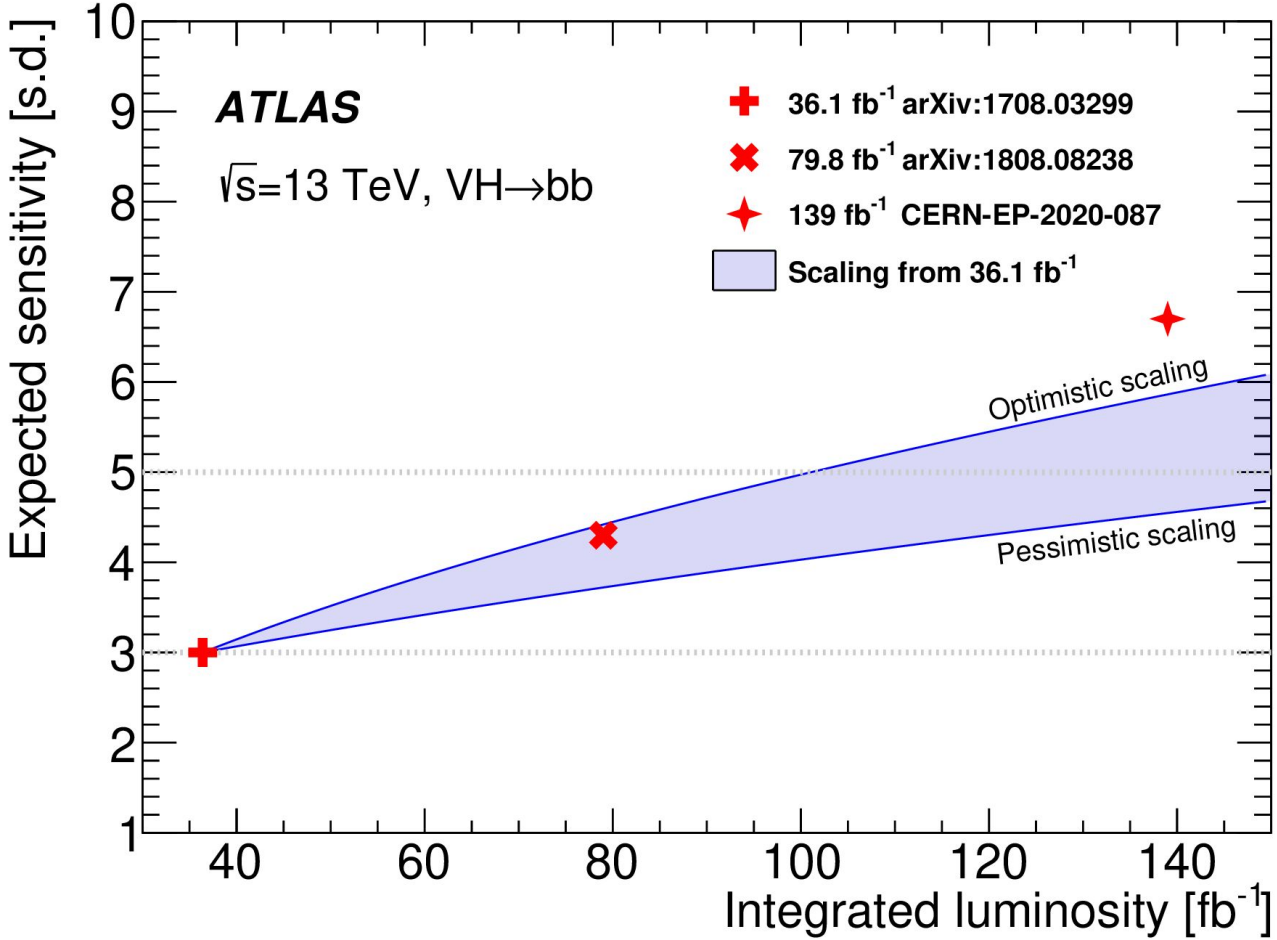
SM width too narrow to measure directly





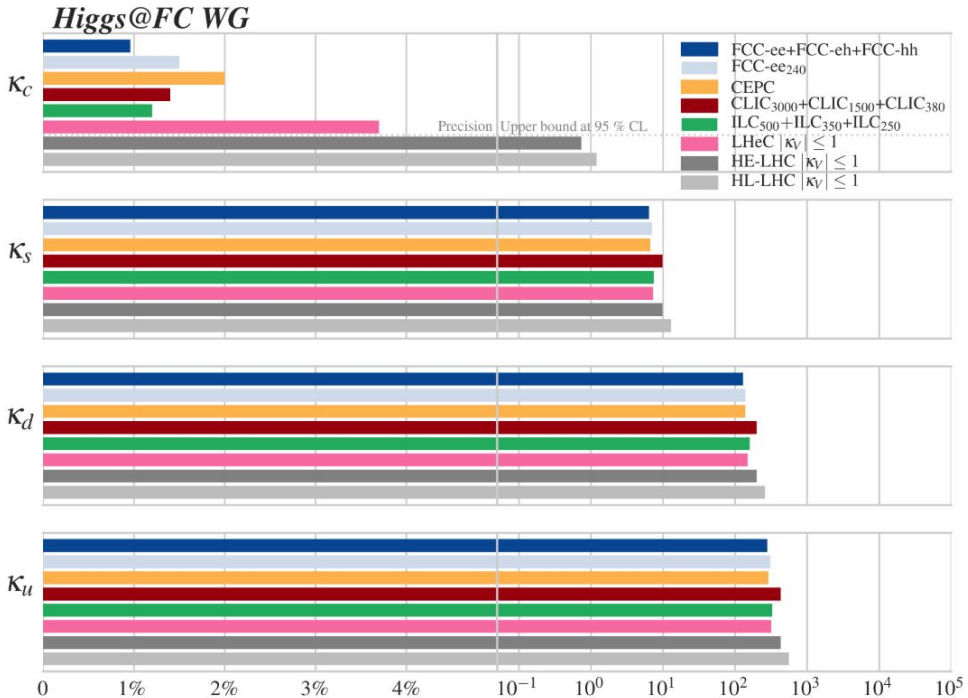


The Future?


ATLAS
√s=13 TeV, VH→bb
36.1 fb-1 arXiv:1708.03299
79.8 fb-1 arXiv:1808.08238
139 fb-1 CERN-EP-2020-087
Scaling from 36.1 fb-1
Optimistic scaling
Pessimistic scaling
Expected sensitivity [s.d.]
Integrated luminosity [fb-1]
10
9
8
7
6
5
4
3
2
1
40
60
80
100
120
140

Conclusions

- ATLAS and CMS have many Higgs boson measurements
- Technically what I showed is still just a subset
- Can expect large improvements in the long and very long term



1905.03764

Backup

References

- Coupling combination
- HH combination
- Differential combination
- Boosted Hbb
- Offshell production
- Mass measurement