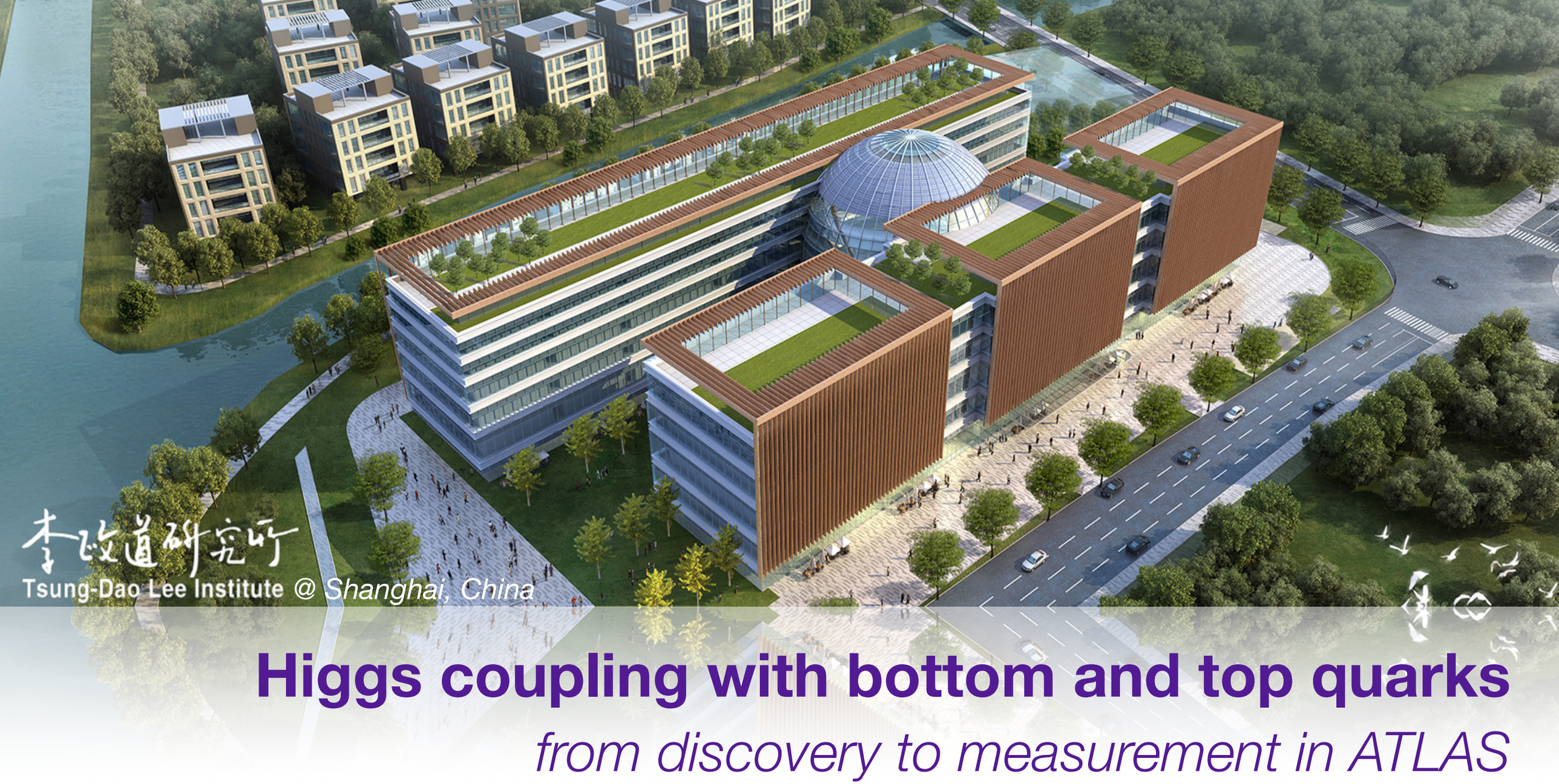

Higgs coupling with bottom and top quarks

from discovery to measurement in ATLAS

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中国物理学会高能物理分会第十三届全国粒子物理学术会议

2021.08.17

Introduction

Introduction

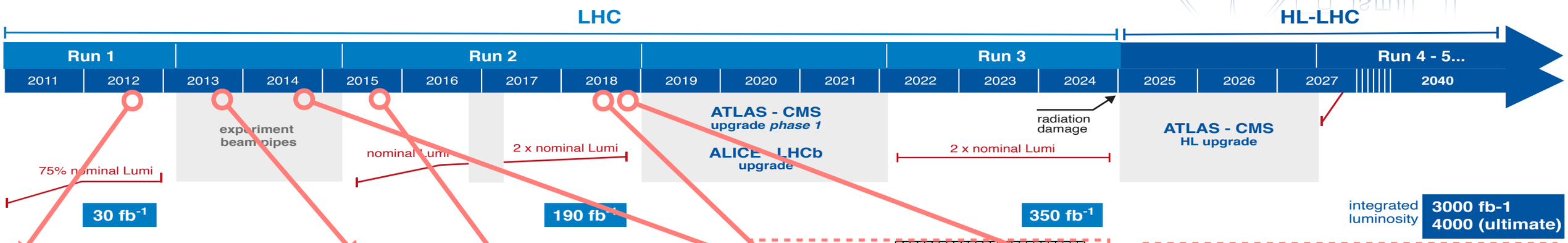
Discovery of Higgs associated production with top-quark pair (ttH)

Discovery of Higgs to bottom-quark pair decay (H→bb)

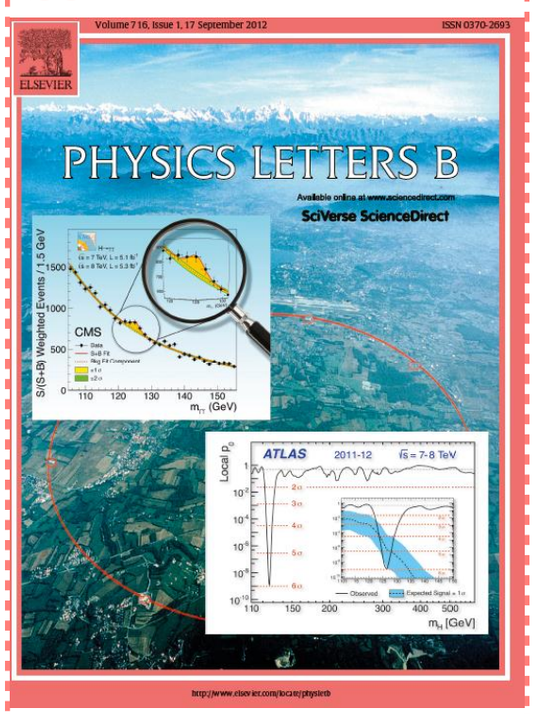
Measurements in ttH channel and in H→bb channel

Summary

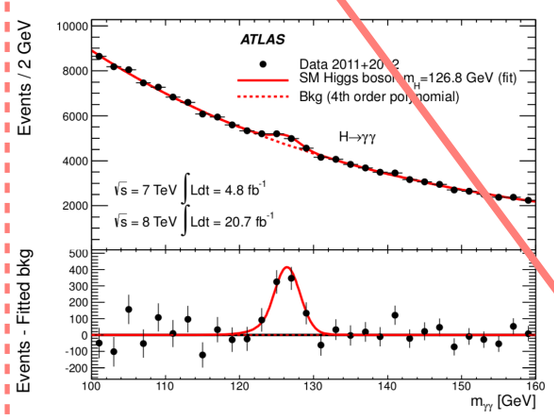
The Higgs boson observation timeline

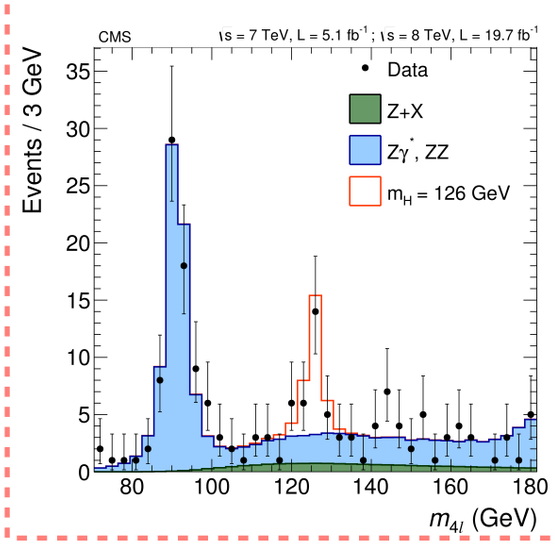


SM-like Higgs discovery
(ggF → $\gamma\gamma$ + ZZ + WW)

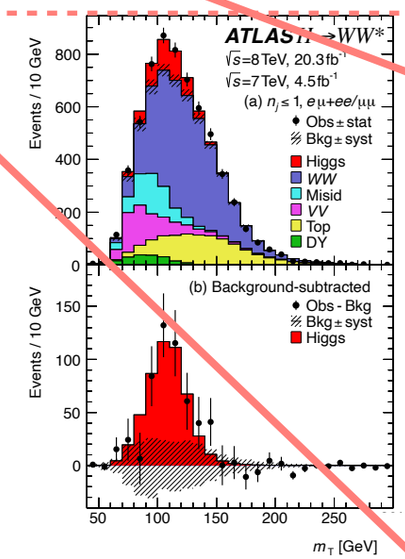


H→$\gamma\gamma$, ZZ→4l observation
(spin-0 and parity +)

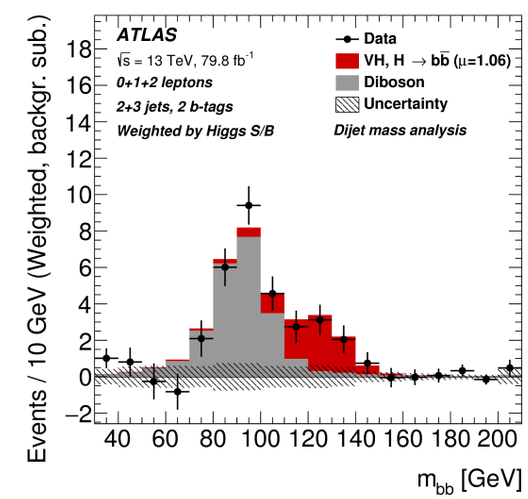




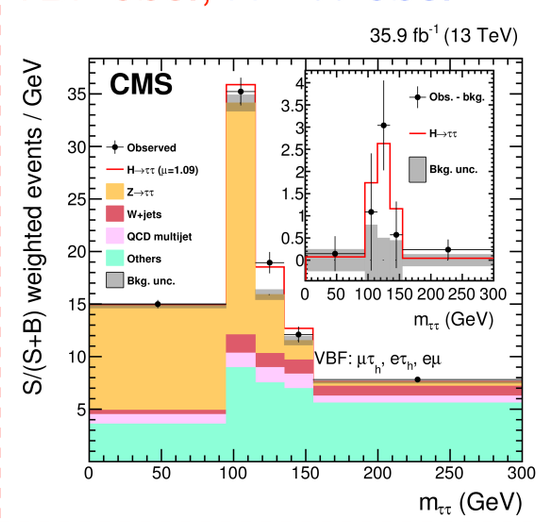
H→WW observation



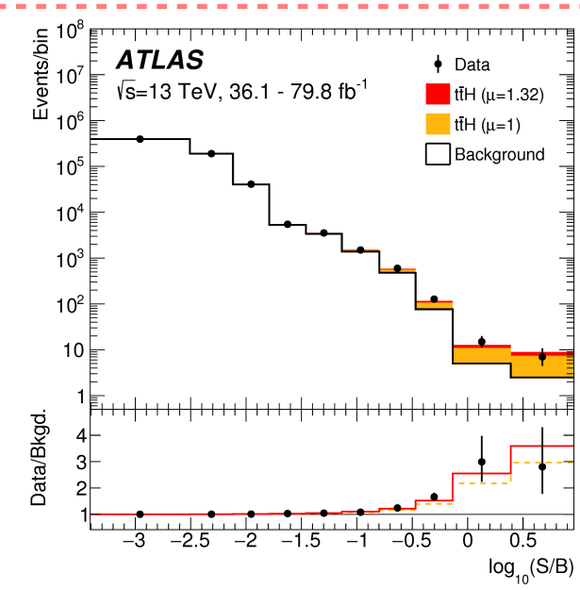
VH, H→bb observation



VBF obs., H→$\tau\tau$ obs.

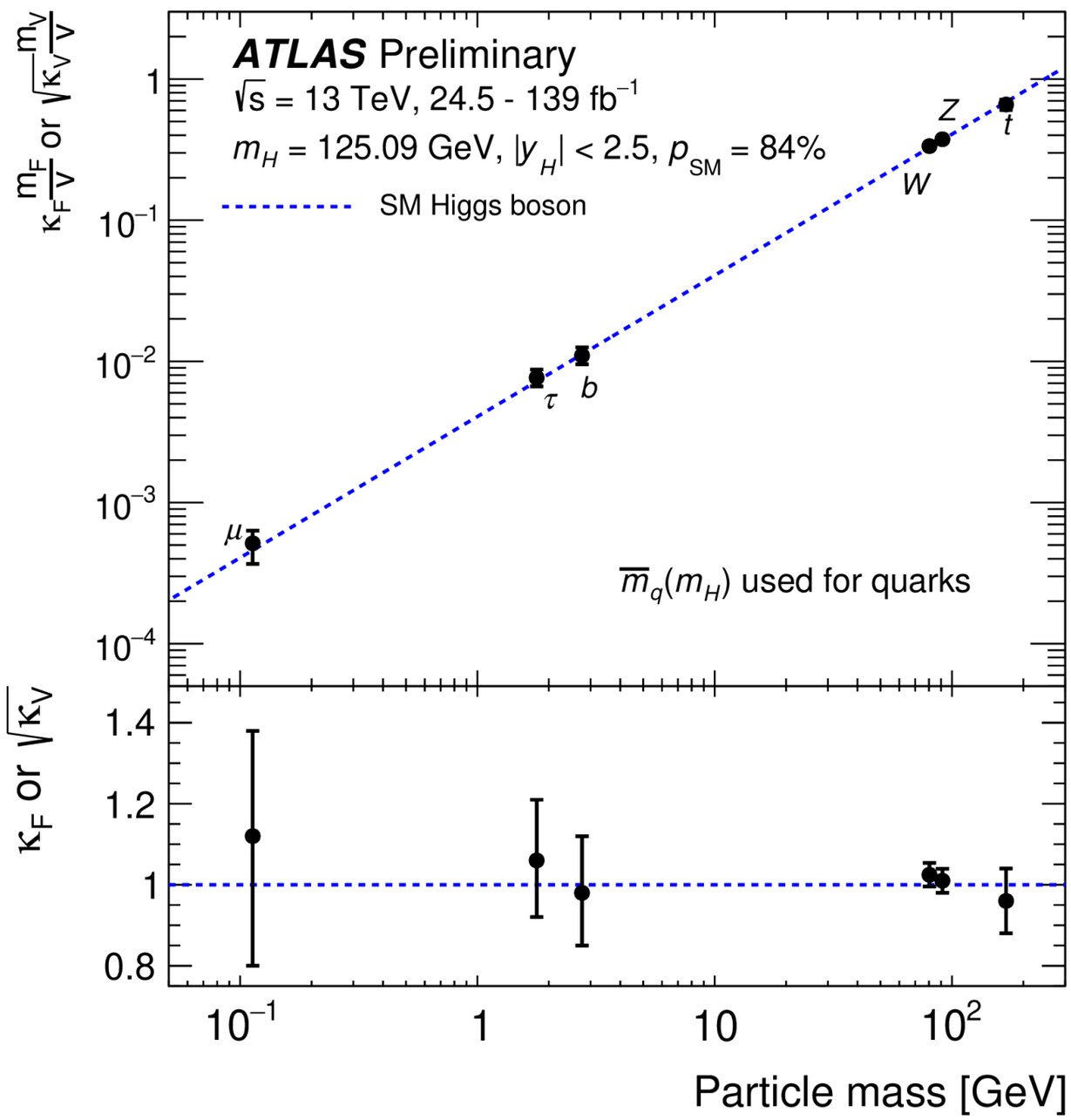


ttH observation



Higgs coupling measurement

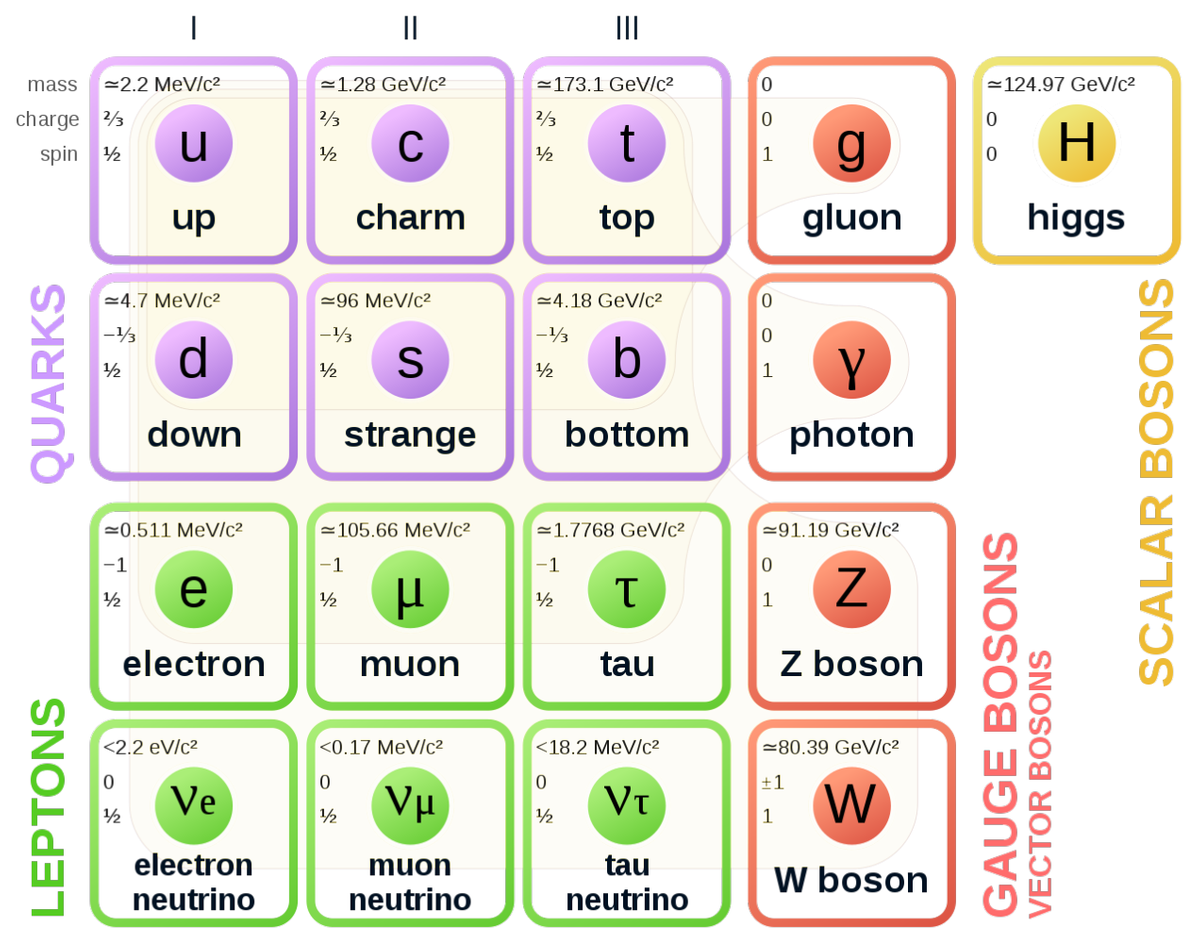
ATLAS-CONF-2020-027



Constraints from the ATLAS experiment:

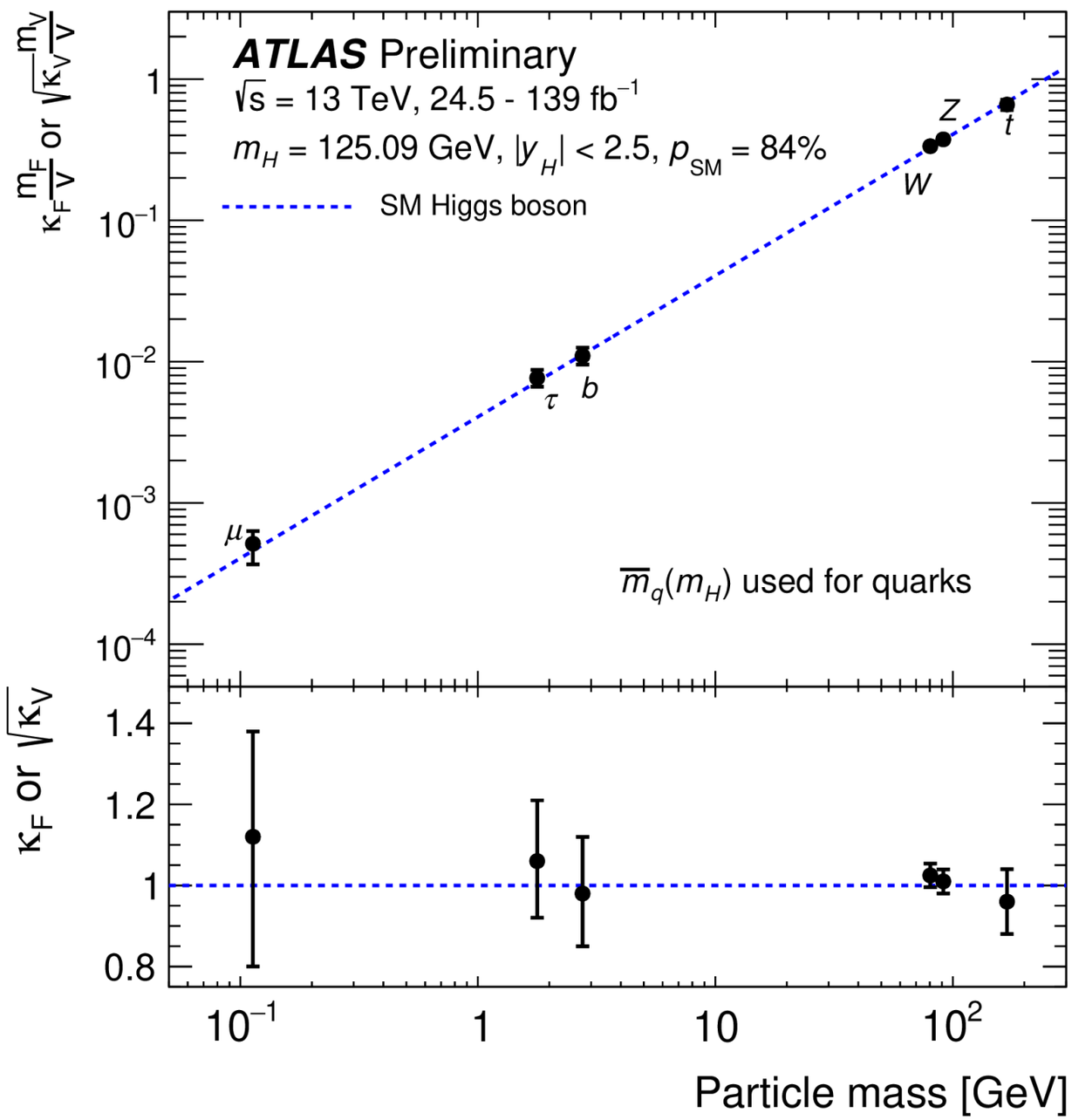
- Higgs-boson coupling uncer. < 10%
- Higgs-fermion coupling uncer. < 15%

All measurements are in good agreement with the SM pred. (84% compatibility).



Higgs coupling measurement

ATLAS-CONF-2020-027



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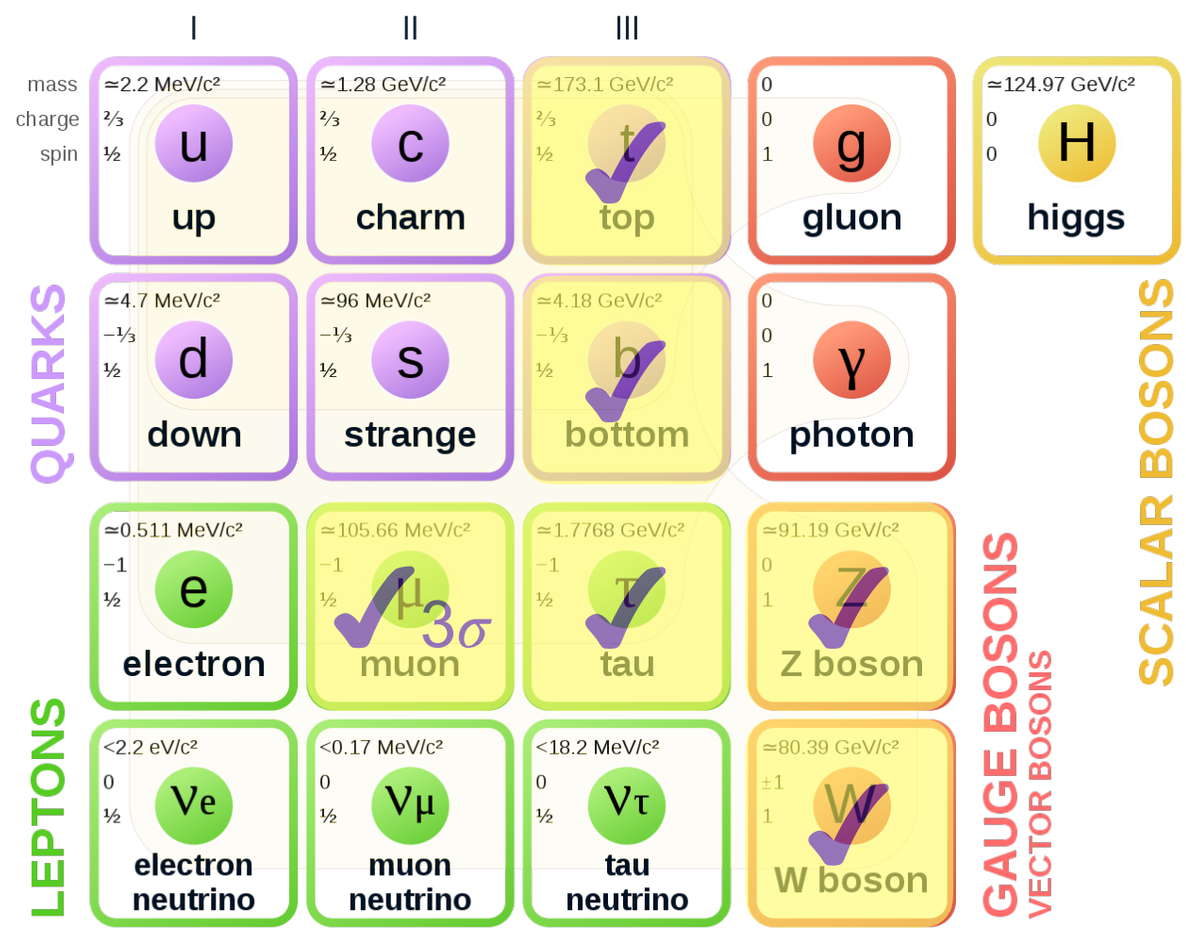
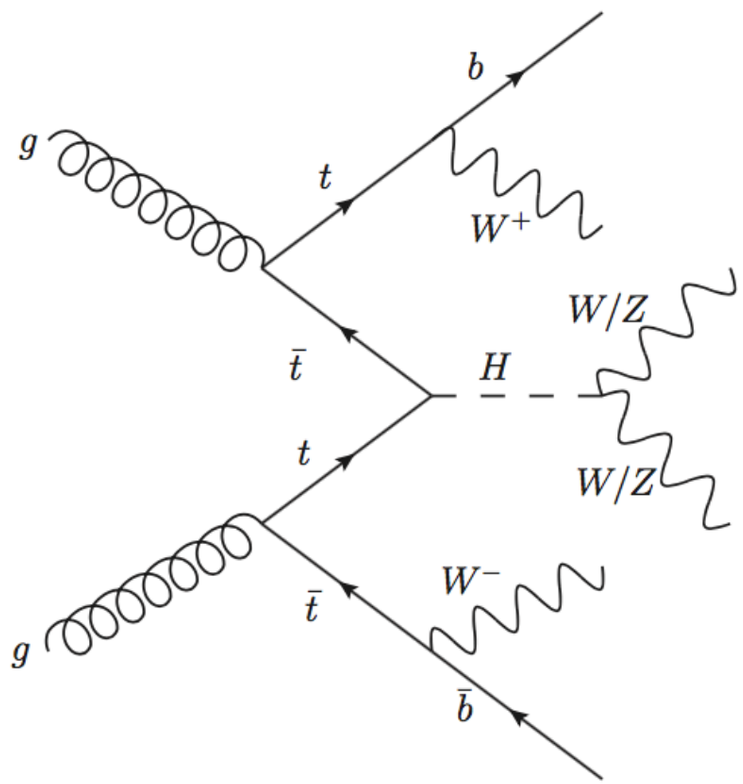


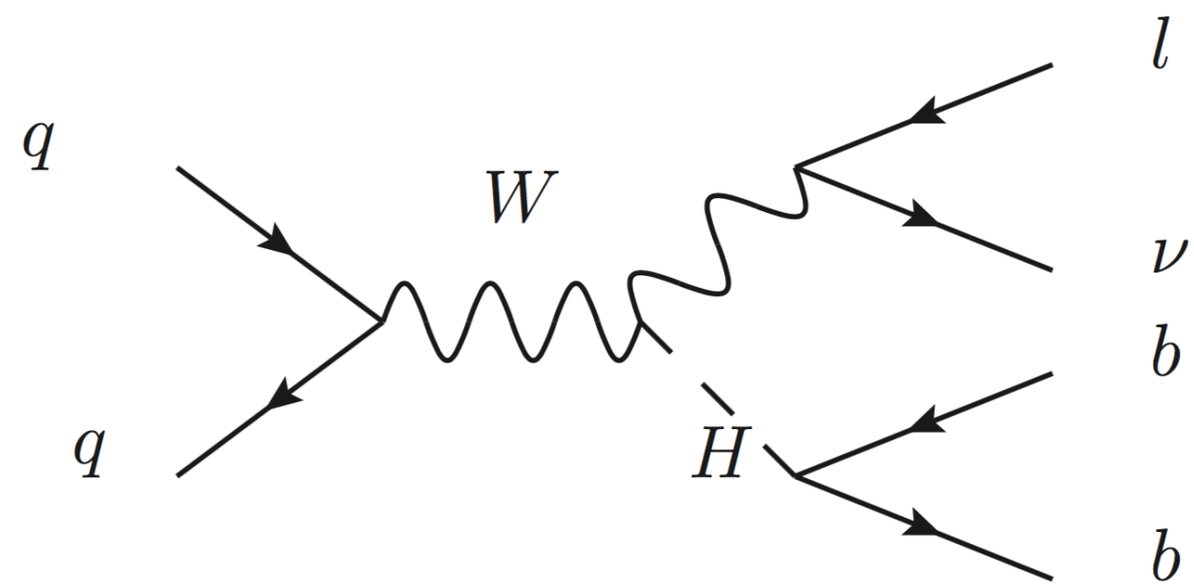
Higgs coupling with top/bottom quarks

Direct measurement of Higgs-top coupling via ttH production.



- Sensitive to New Physics.
- Small ttH production rate, only ~1% of Higgs production.
- Complex final states, challenge in signal event reconstruction.

Direct measurement of Higgs-bottom coupling via H→bb decay.

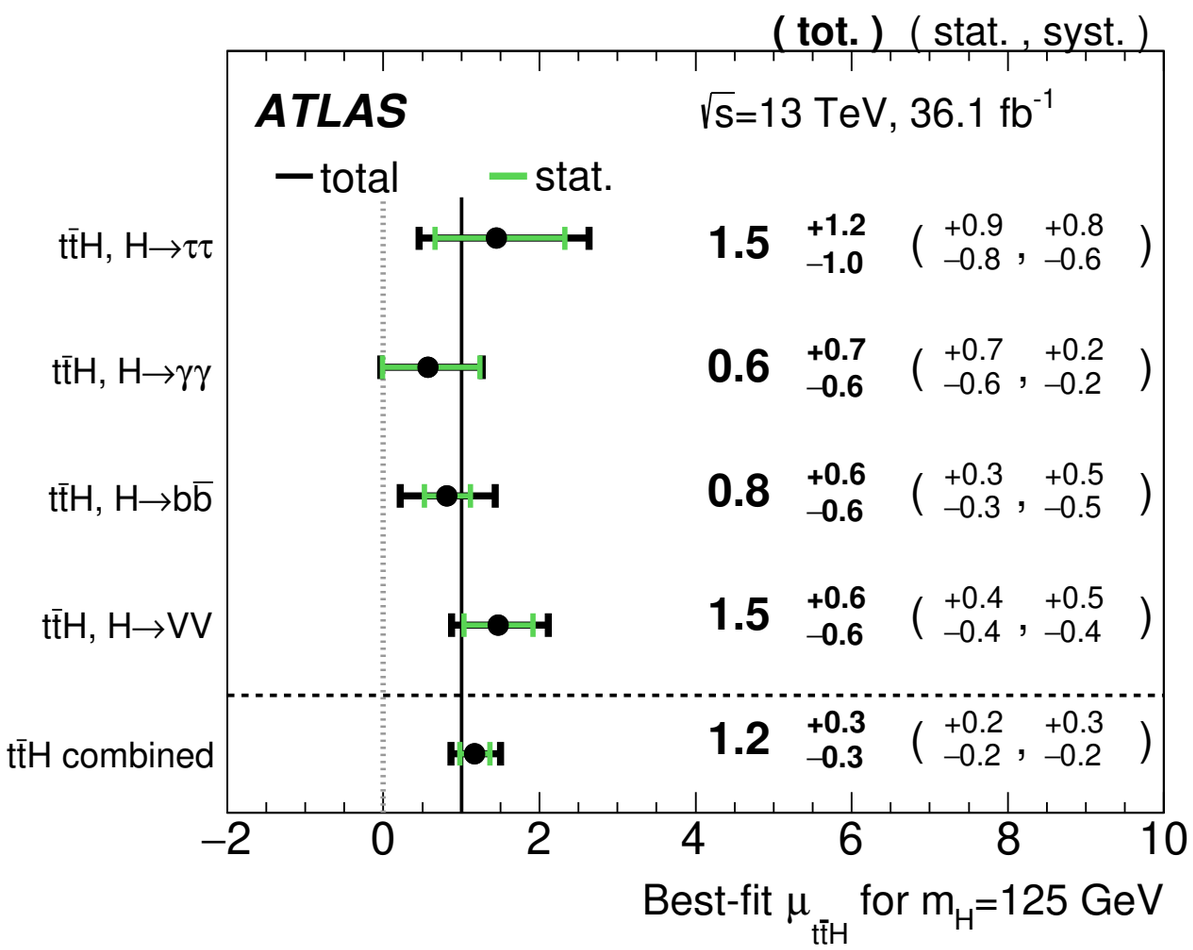


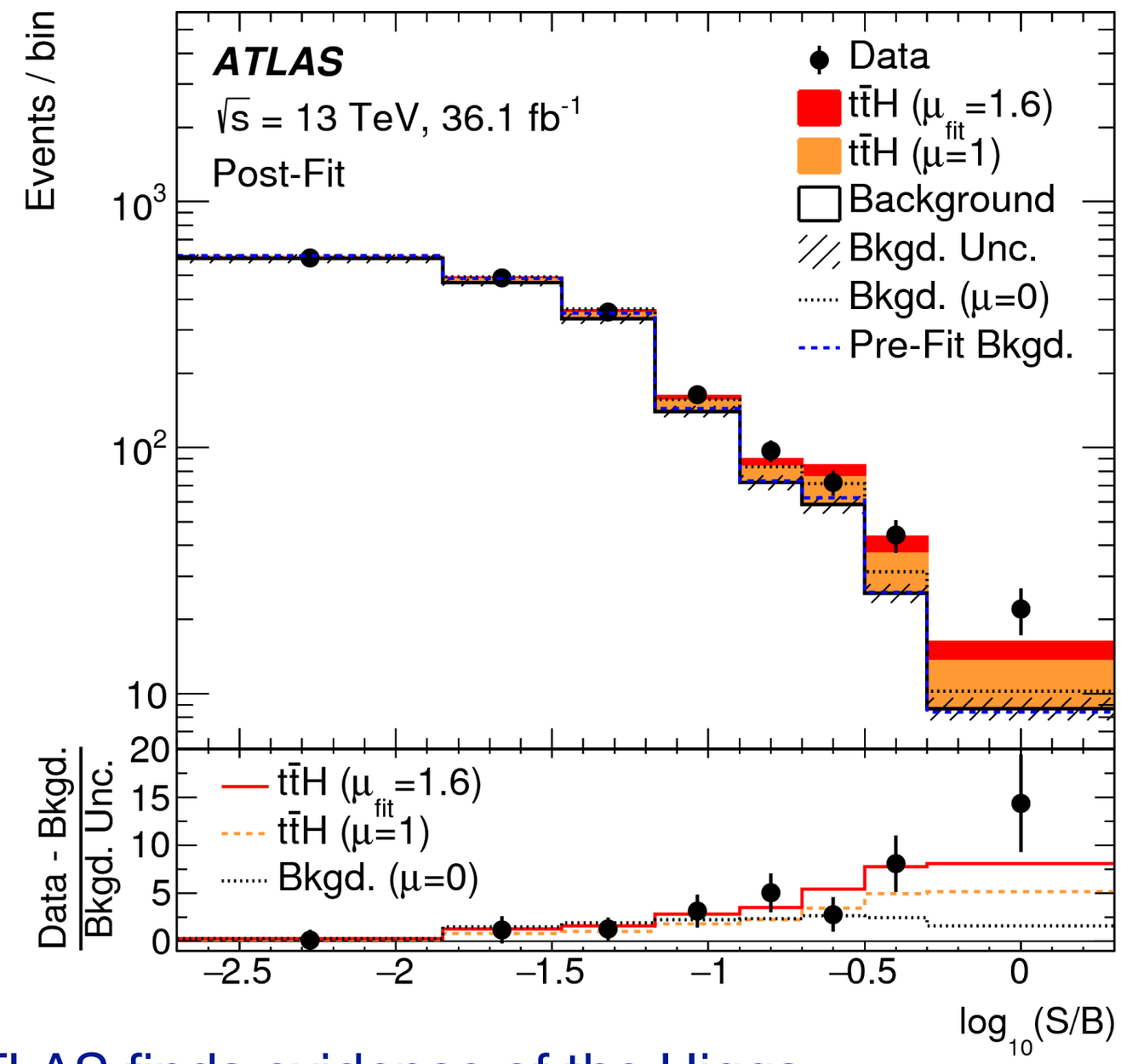
- H→bb has the largest decay branching ratio, ~58%.
- It's challenge to reduce huge background pollution.

Direct evidence of Higgs-top coupling

Combining all decay channels, the observed significance is 4.2σ with 36.1 fb^{-1}.

Multi-lepton channels have dominate contribution.



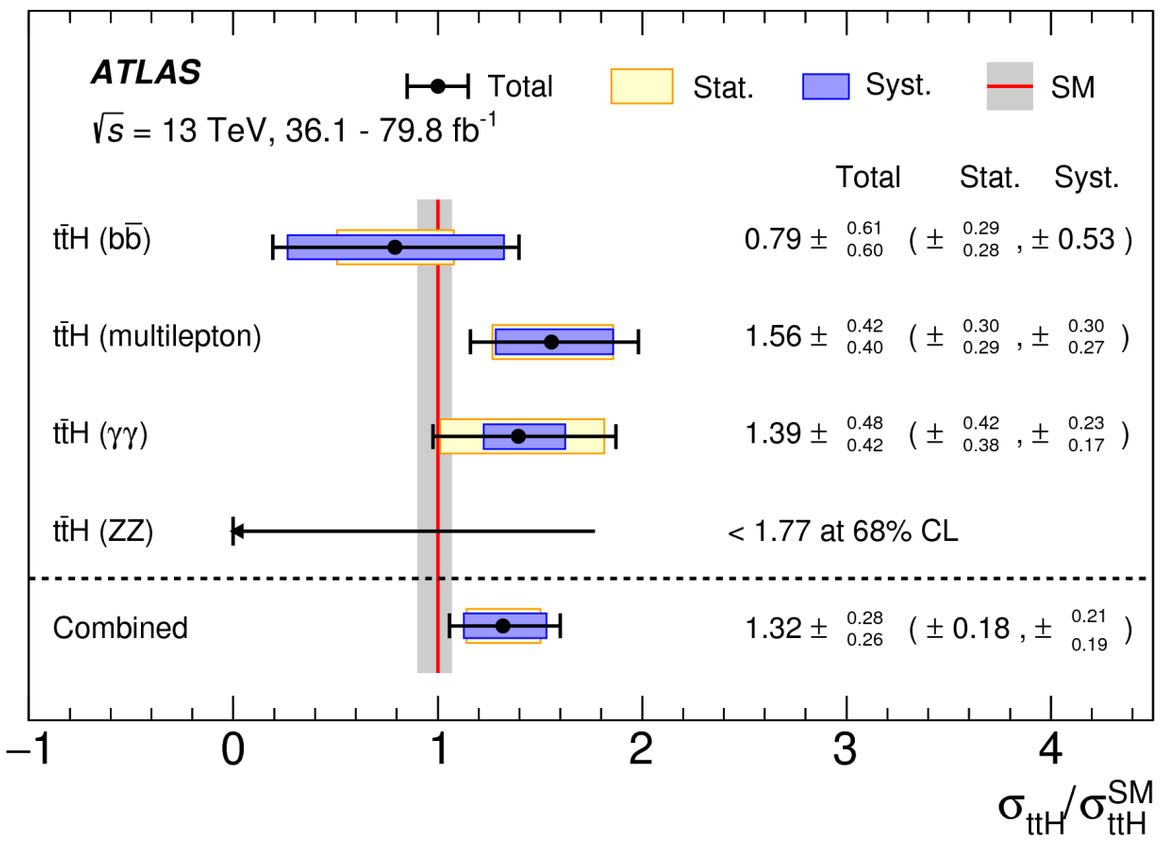


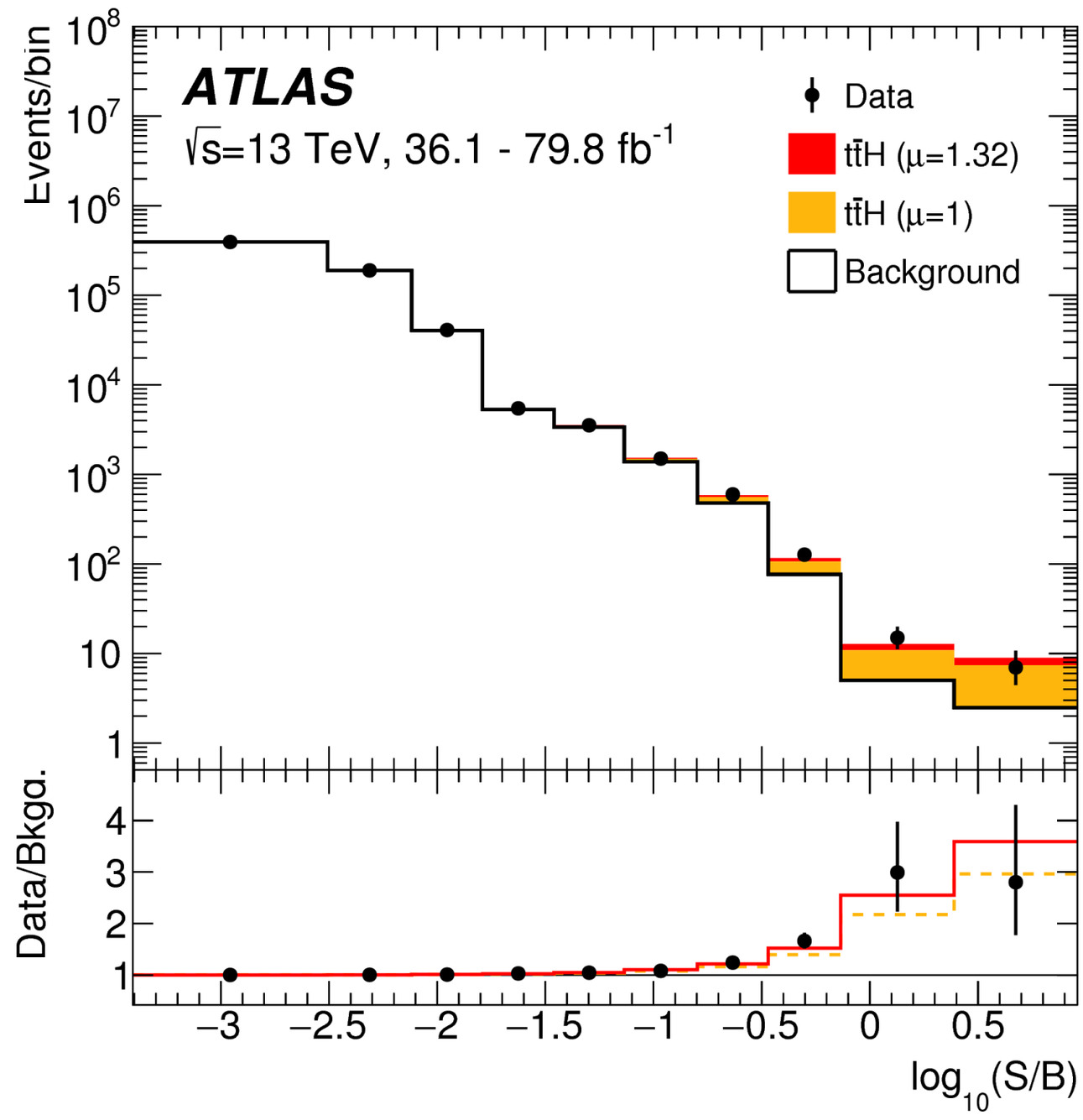
[ATLAS physics briefing (2017.10): ATLAS finds evidence of the Higgs boson produced in association with a pair of top quarks]

Direct observation of Higgs-top coupling

Half years later, ttH&H→$\gamma\gamma$ channel was updated to 79.8 fb^{-1} luminosity.

Combining all channels, the observed significance is 5.8σ.

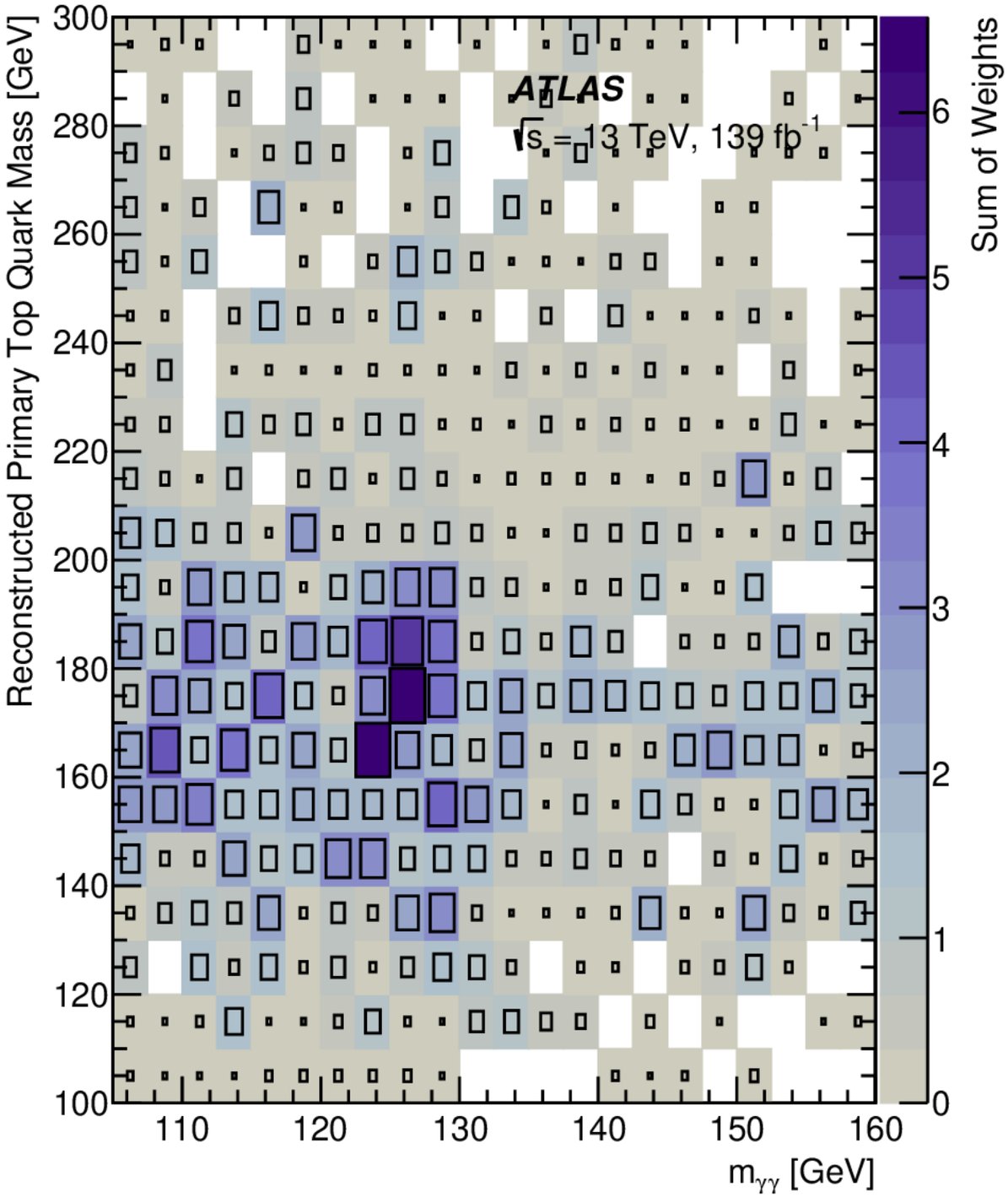


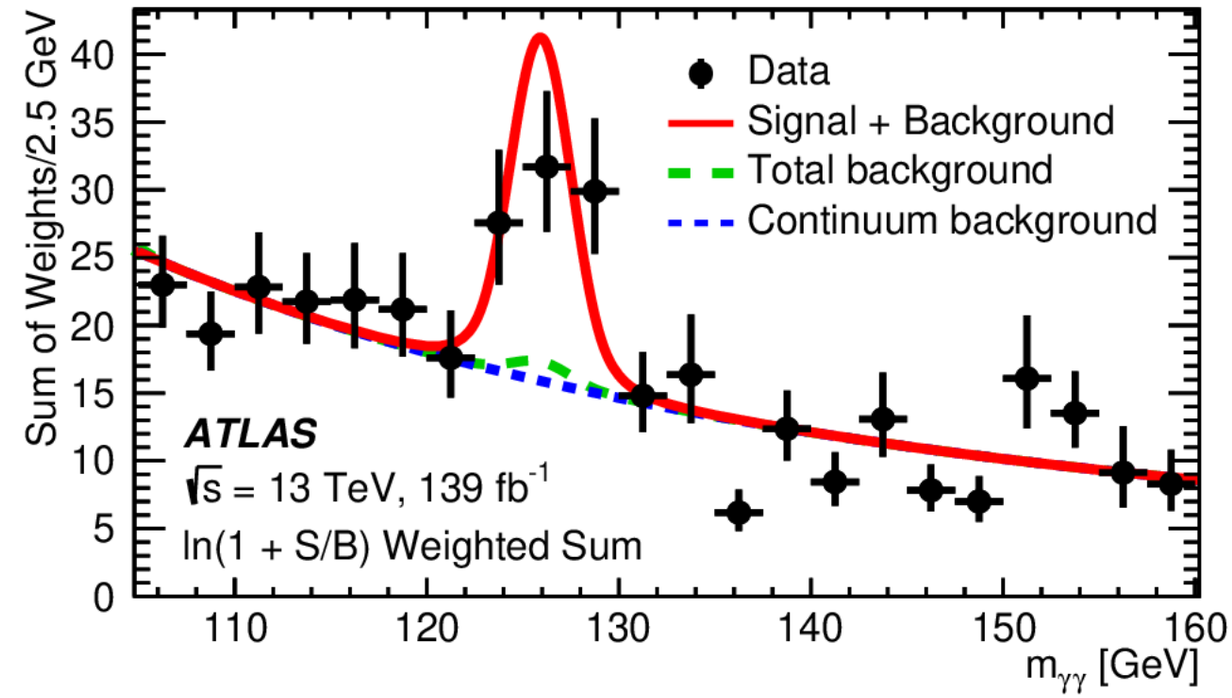


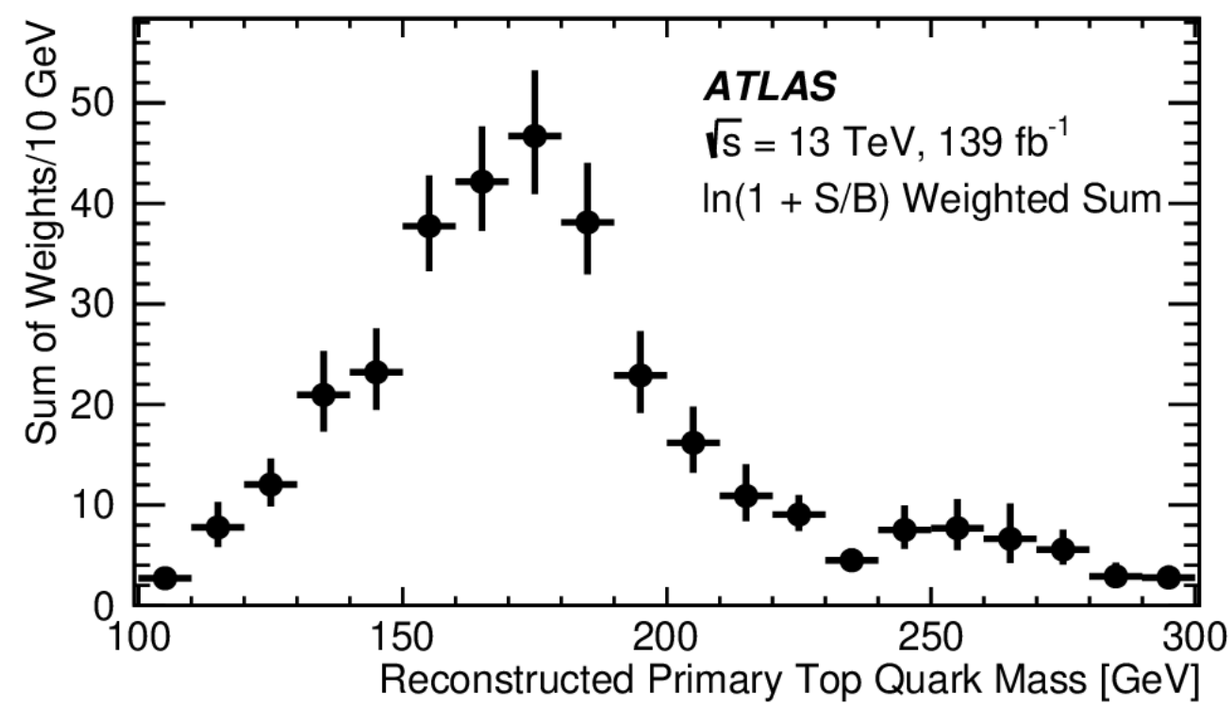
[ATLAS physics briefing (2018.6): New ATLAS result establishes production of Higgs boson in association with top quarks]

ttH, H→γγ channel updates with 139 fb^{-1}

Event reconstruction

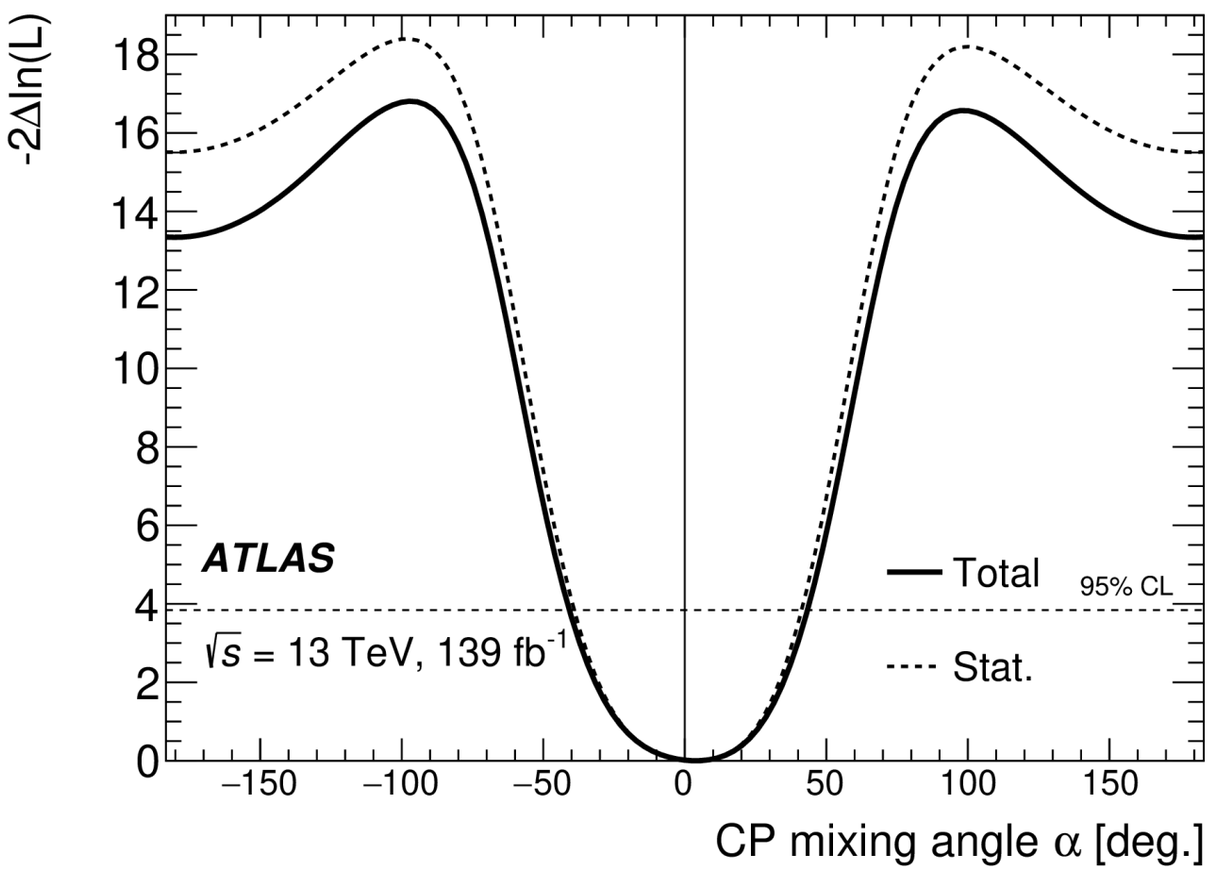


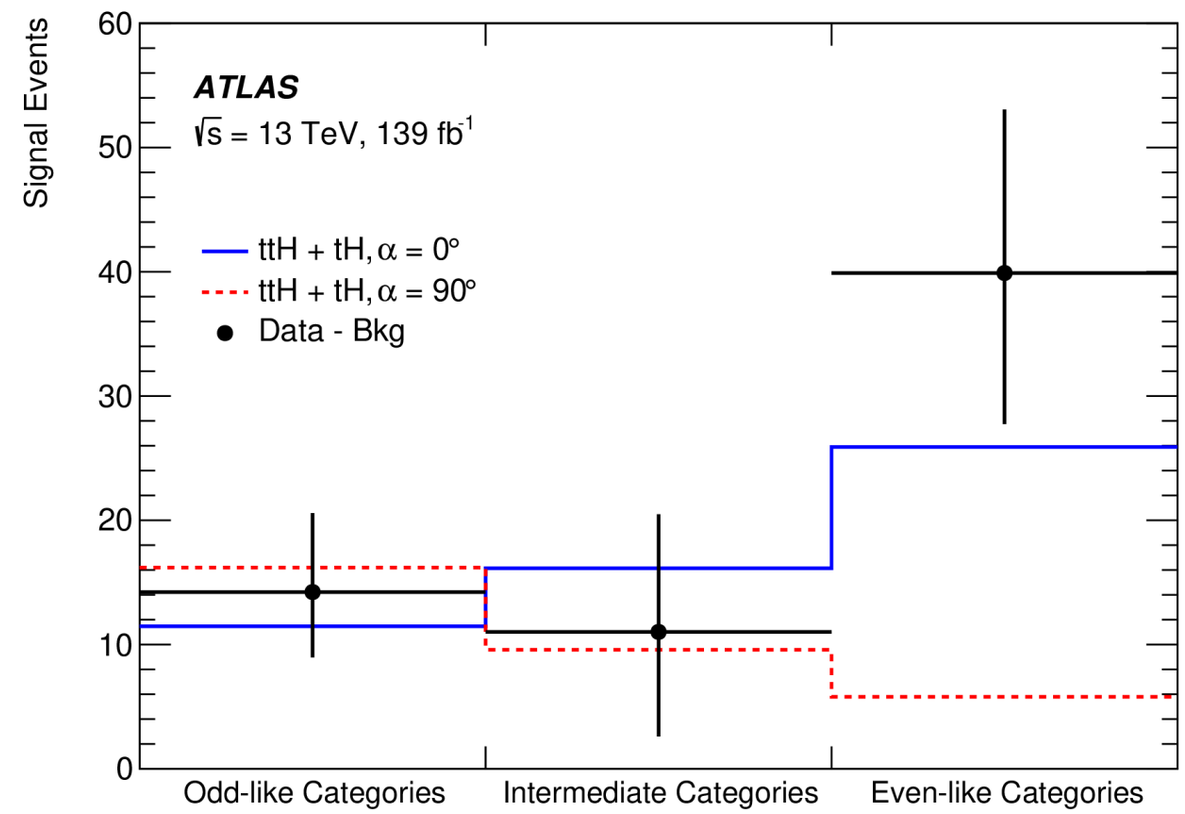




ttH, H→γγ channel updates with 139 fb^{-1}

- Using 139 fb^{-1} dataset, ttH is observed in the H→**γγ** channel with 5.2σ significance (assuming CP-even coupling).
- A CP-mixing angle greater than 43(-43)^0 is excluded at 95% confidence level.
- The data disfavors the pure CP-odd model of the Htt coupling at 3.9σ.

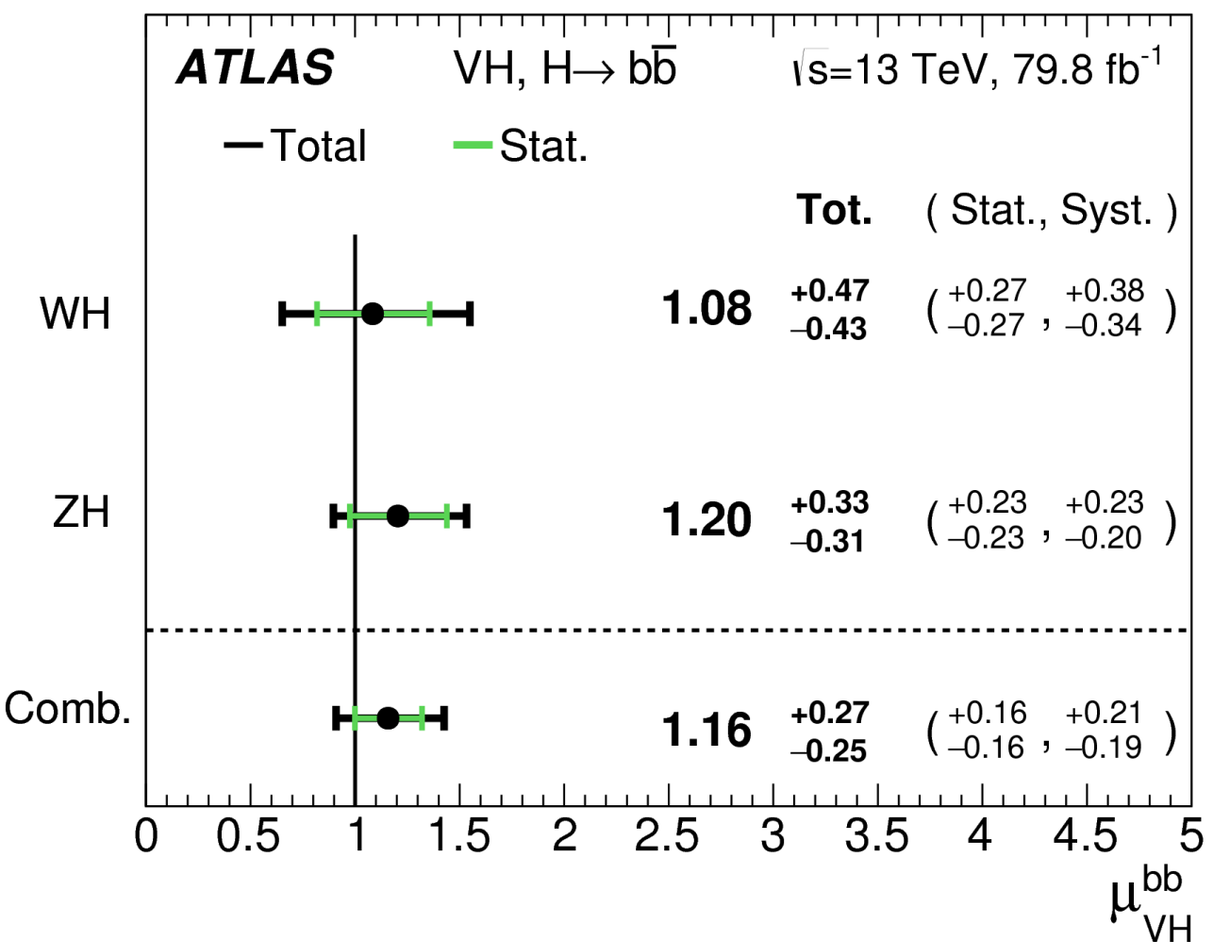


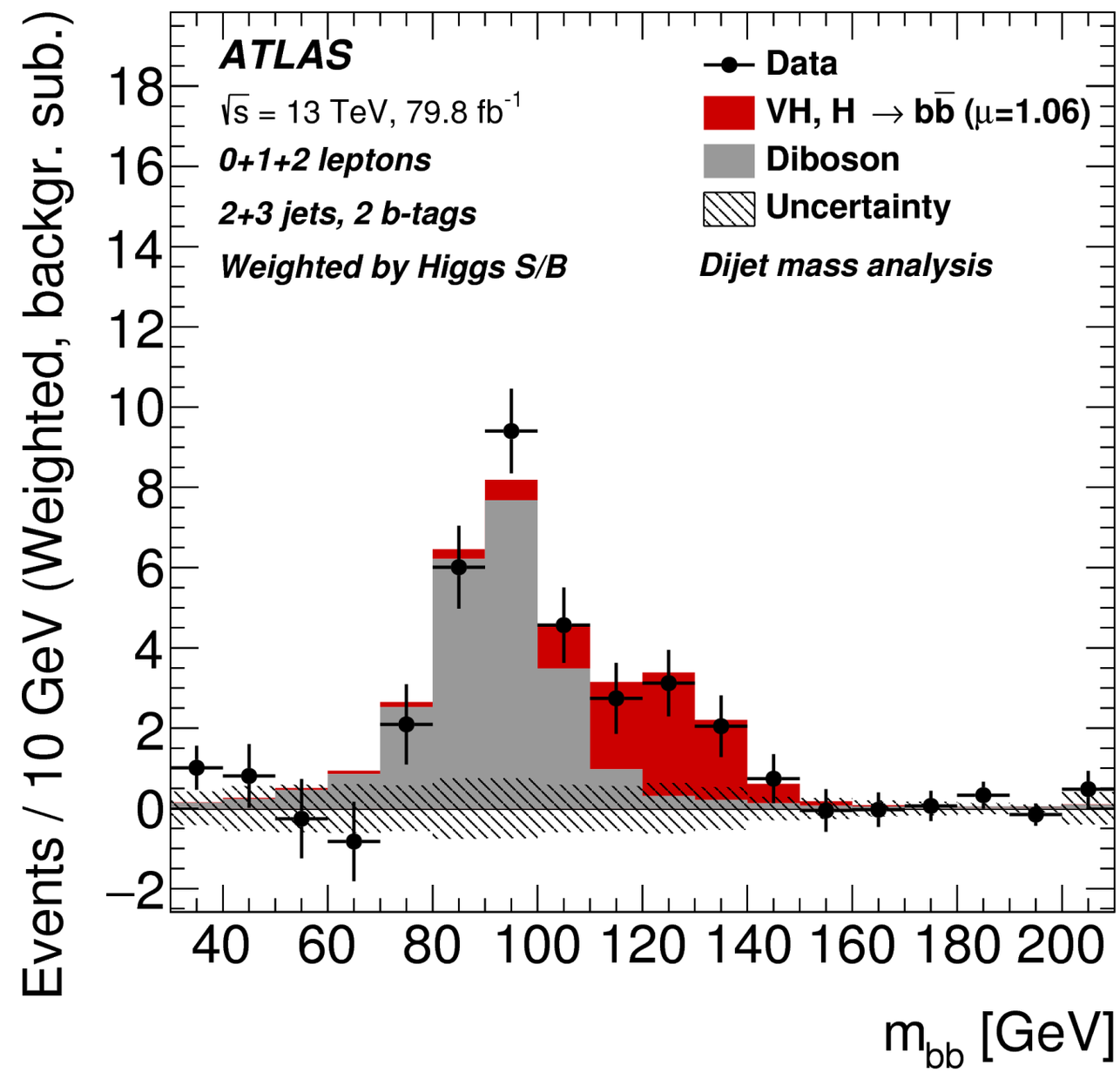


ATLAS physics briefing (2020.4): Searching for new sources of matter–antimatter symmetry breaking in Higgs boson interaction with top quarks

Discovery of Higgs to bottom-pair decay

Using 79.8 fb^{-1} dataset, the observed significance for VH, H→bb process is 4.9σ. Combing with Run 1, the significance is 5.4σ.

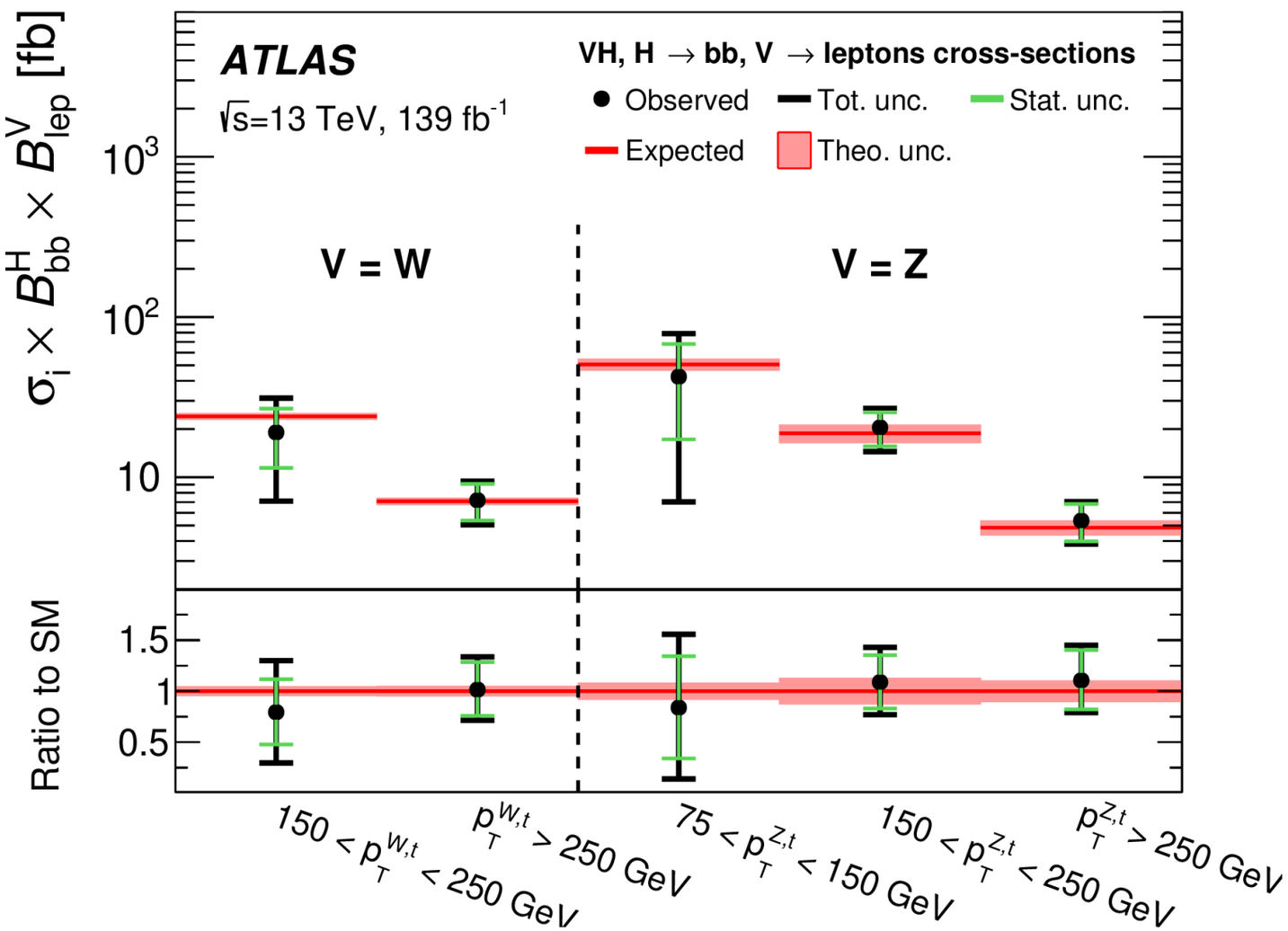


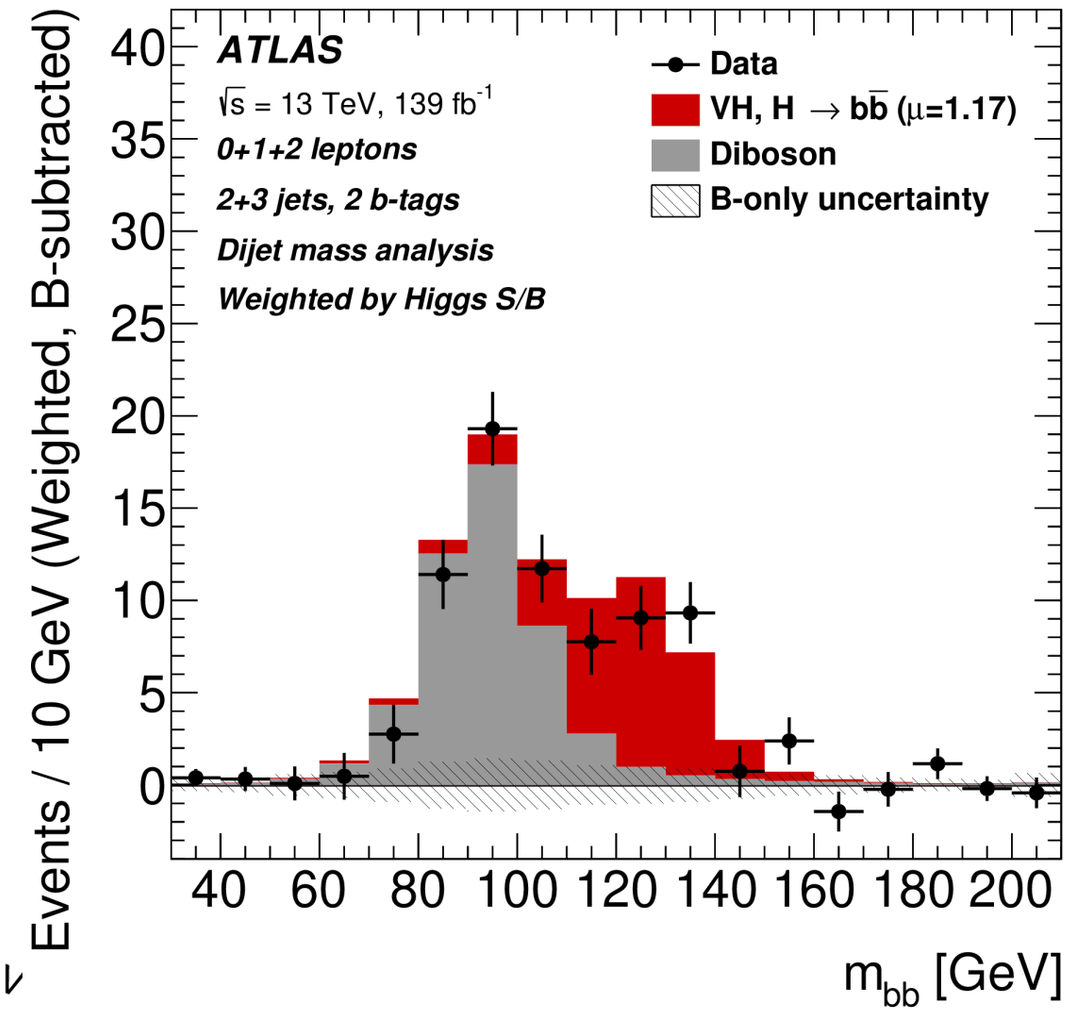


[ATLAS physic briefing (2018.7): Higgs boson observed decaying to b quarks - at last!]

VH, H→bb cross section measurement

The result has been updated to 139 fb^{-1}. Cross sections have been measured as a function of the gauge boson transverse momentum in kinematic fiducial volumes (simplified template cross section).

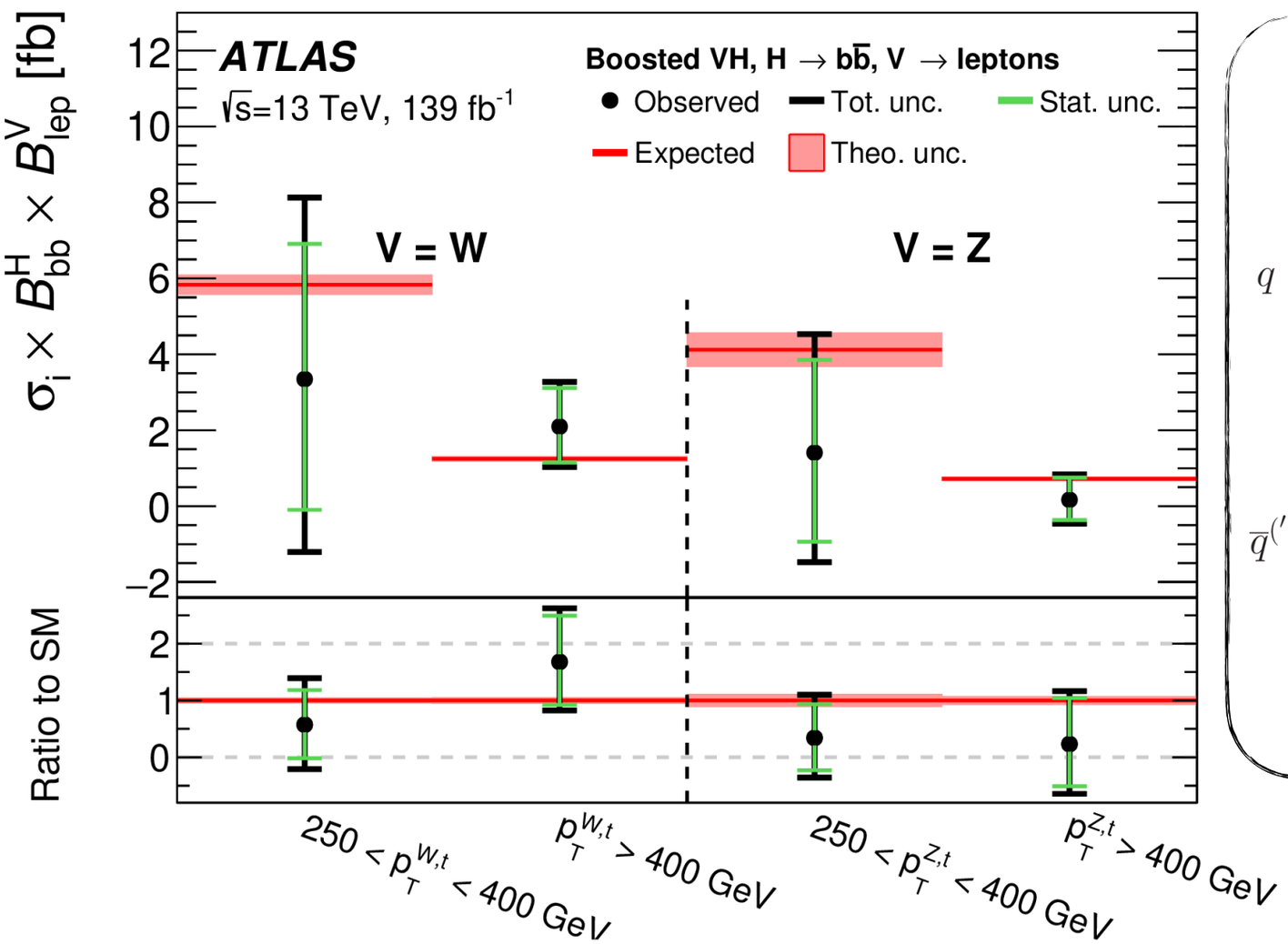


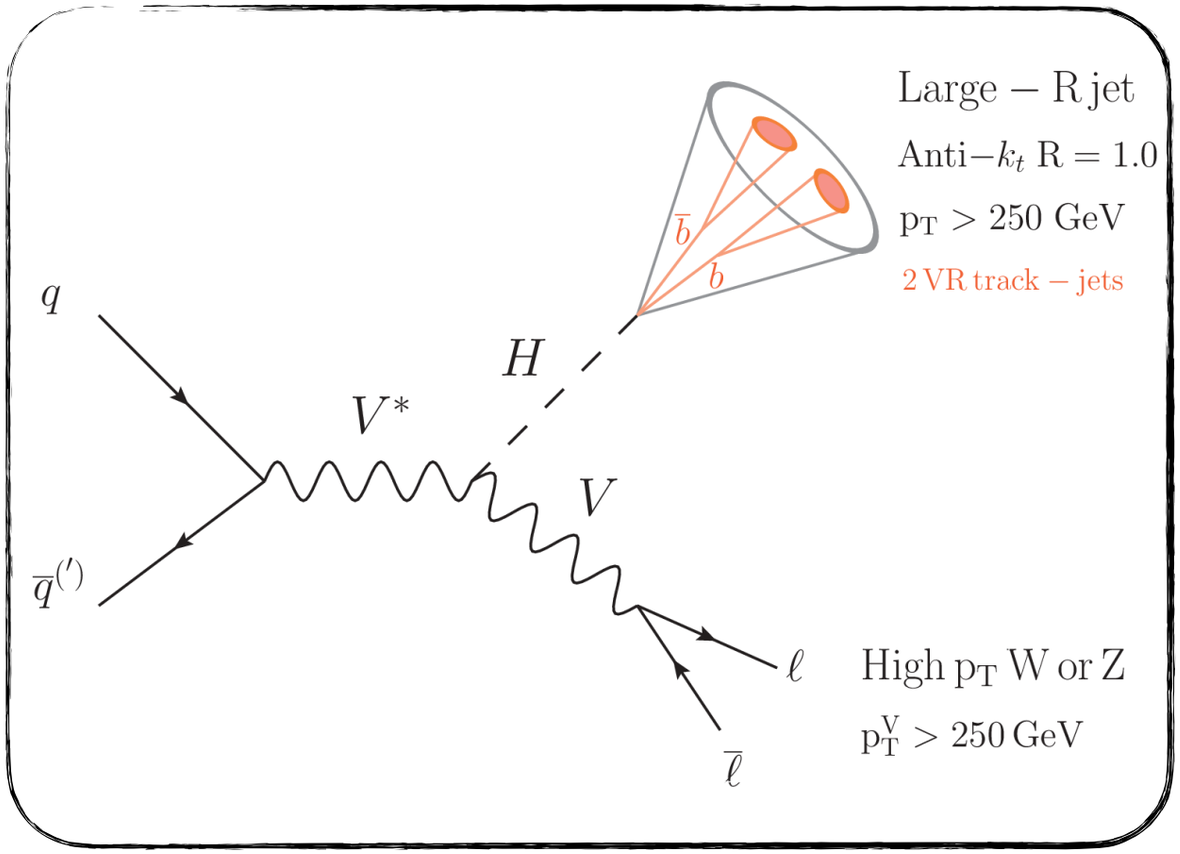


ATLAS physics briefing (2020.4): Measuring the beauty of the Higgs boson

VH, H→bb cross section measurement

Measurement in the high vector-boson transverse momentum regime, above 250 GeV, using 139fb^{-1} dataset.

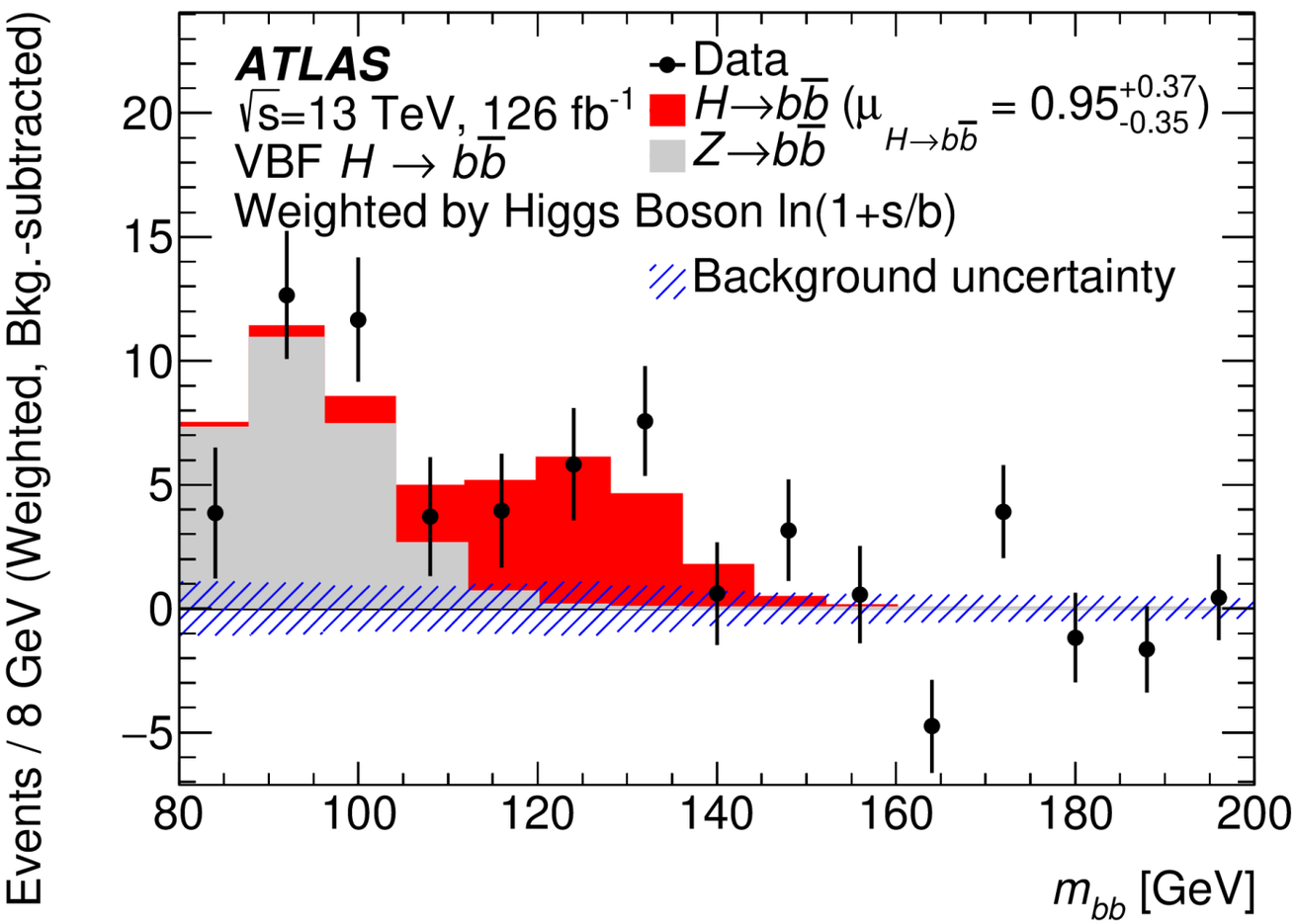


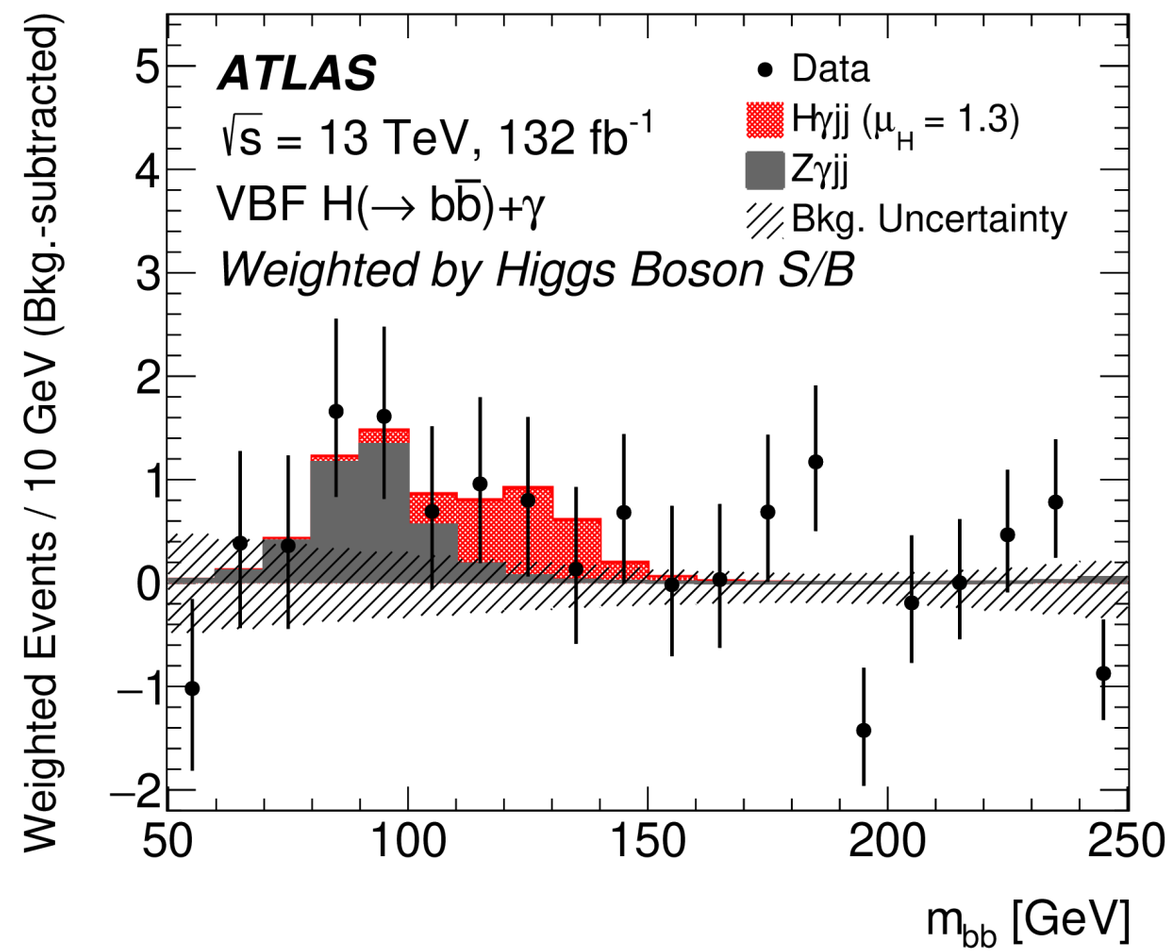


ATLAS physics briefing (2020.4): Measuring the beauty of the Higgs boson

VBF, H→bb process searches

Search for VBF, H→bb has been performed in inclusive channels (left) and VBF+γ (right) channels. The observed significances are 2.9σ and 1.3σ.





[ATLAS physics briefing (2020.12): Studying the Higgs boson in its most common – yet uncommonly challenging – decay channel]

Summary

- It's a milestone to observe the H→ bb channel and the ttH production
  - ✓ direct observation of Higgs coupling with bottom/top-quark
- These two channels have turned to measurements
  - ✦ fiducial and differential cross-sections
  - ✦ CP properties, etc.
- Full Run 2 analyses are still on-going (legacy paper)
  - ✦ ttH&H→bb channel, ttH in multi-lepton channel, tH production
  - ✦ H→bb resolved and boosted combination, combination with H→cc

Please stay tuned !