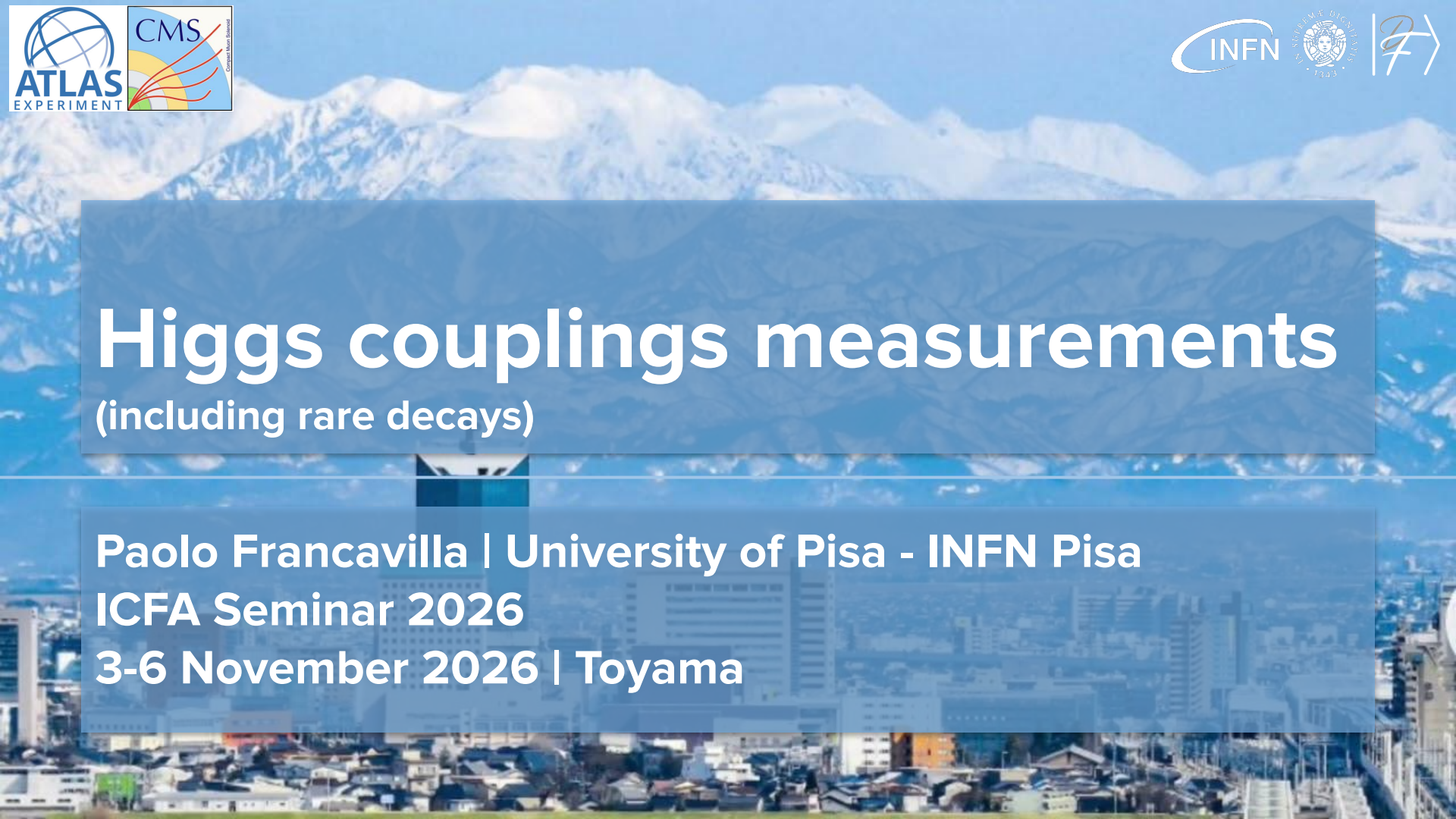


Higgs couplings measurements

(including rare decays)

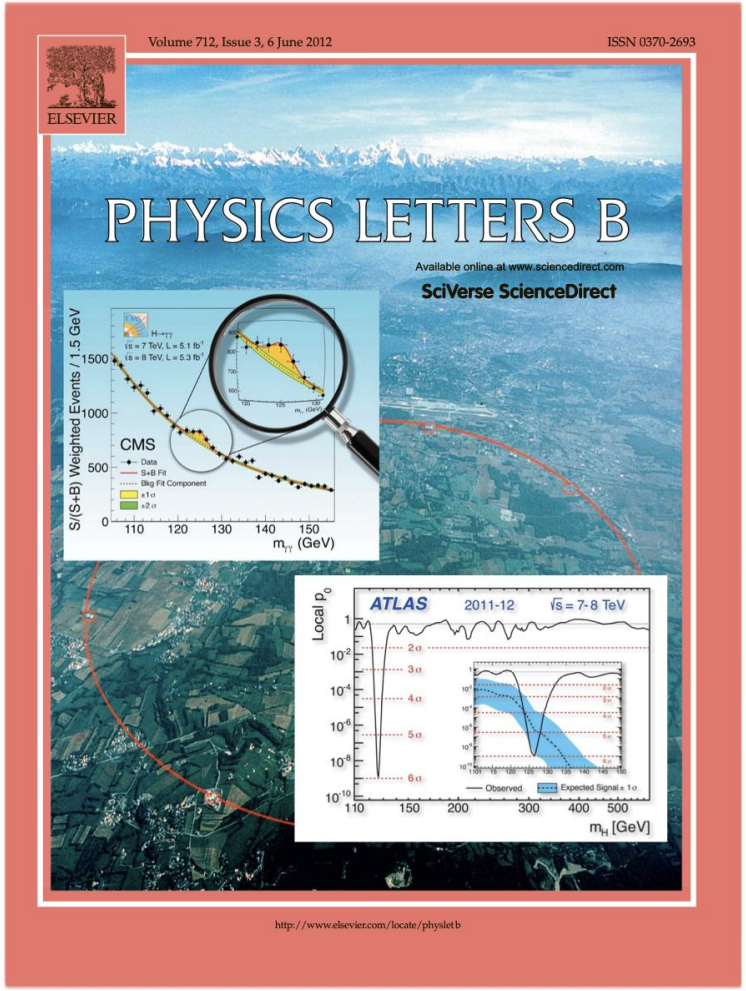
Paolo Francavilla | University of Pisa - INFN Pisa

ICFA Seminar 2026

3-6 November 2026 | Toyama

The Higgs boson discovery

- The **Higgs boson was discovered** by the **ATLAS** and **CMS** experiments at the **LHC in 2012**, marking a **major milestone** in particle physics.
- Its discovery opened **new avenues for exploring the electroweak sector.**
- Extensive **measurements of its properties** have enabled increasingly **precise tests of the Standard Model (SM)**.
- Deviations from SM predictions could provide evidence of new physics.



The Higgs field and the Standard Model particles

- **Brout-Englert-Higgs mechanism:** spontaneous ElectroWeak Symmetry Breaking generates W and Z masses within a consistent gauge theory

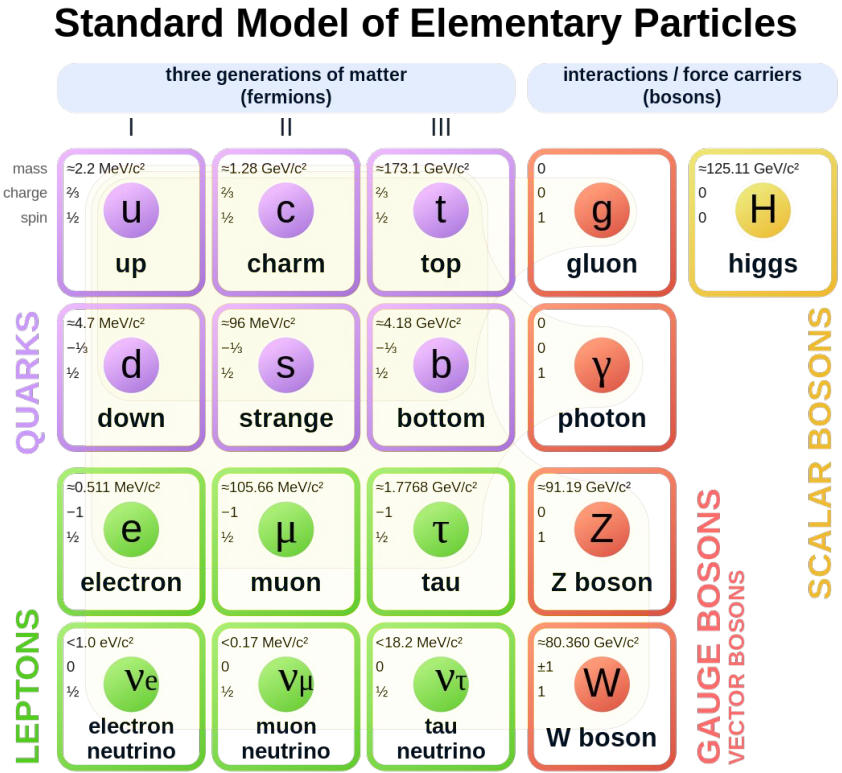


The Nobel prize in Physics 2013
P. Higgs, F. Englert

- **In our everyday life -** among the other effects:
  a. proton–neutron mass splitting
  b. set atomic sizes,
  c. stellar weak-reaction rates.

adaptation from Salam, G.P., Wang, LT. & Zanderighi, G. The Higgs boson turns ten. *Nature* **607**, 41–47 (2022)

The Higgs field shapes the world we know.



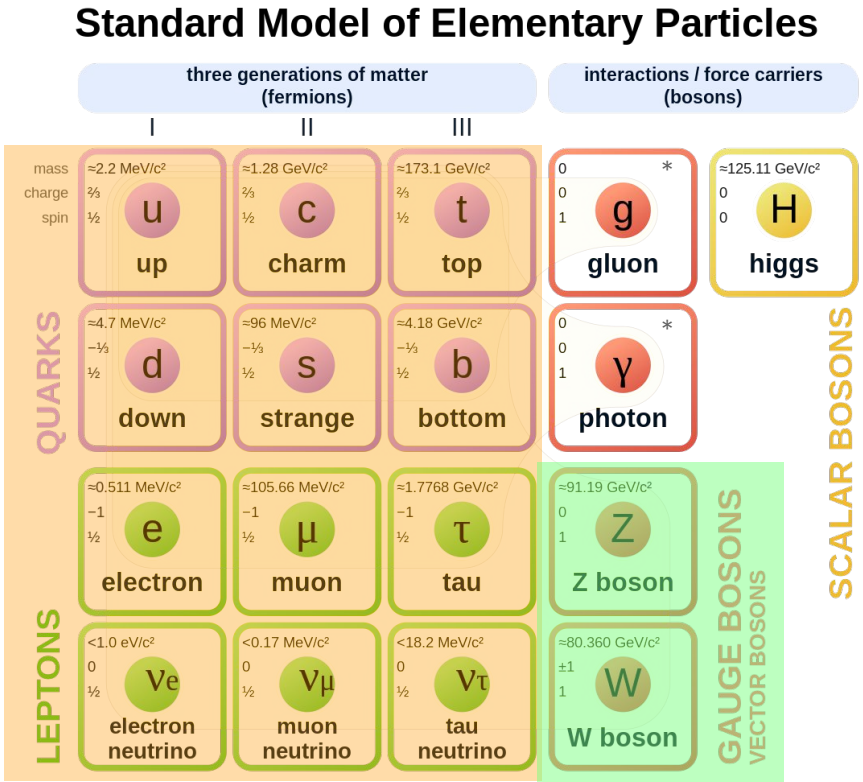
What makes the Higgs boson special?

Higgs field interactions:

- **Vector bosons:** the (HWW) and (HZZ) couplings test the mechanism responsible for the **W and Z masses in the electroweak symmetry breaking.**

- **Fermions:** Yukawa couplings reveal a **distinct fundamental interaction.** Their hierarchy encodes the fermion mass hierarchy, whose origin remains unexplained.

An experimental window:
The **measurements of the Higgs boson** *production* and *decay* modes let us **infer its couplings**
=> consequently the Higgs field couplings

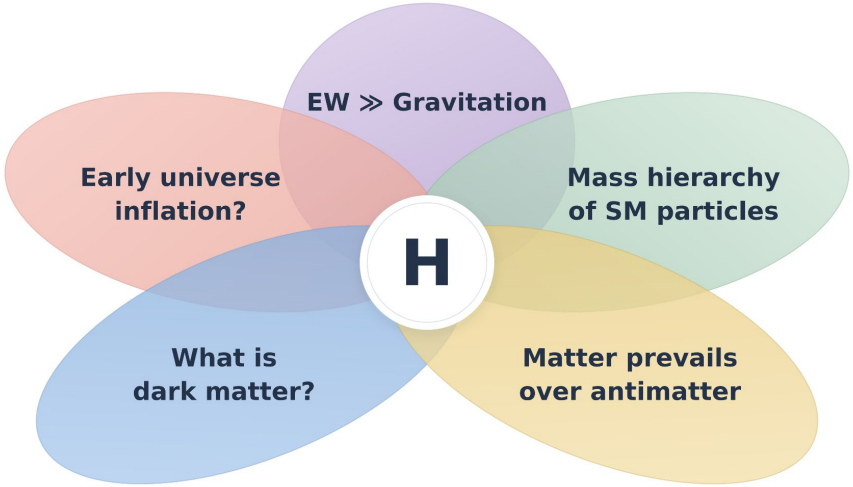


* in the SM, via loop

Unanswered questions and the Higgs field

Higgs field is central tool to investigate some of the **fundamental questions** in the **understanding of our Universe**:

- **Range of the fermion masses**
- **Higgs and Dark matter**
- **Matter-Antimatter asymmetry**
- **Unification of interactions**
- **Stability of the universe**
- **Cosmological observations and gravitational waves**



Adaptation from Salam, G.P., Wang, LT. & Zanderighi, G. The Higgs boson turns ten. *Nature* **607**, 41–47 (2022)

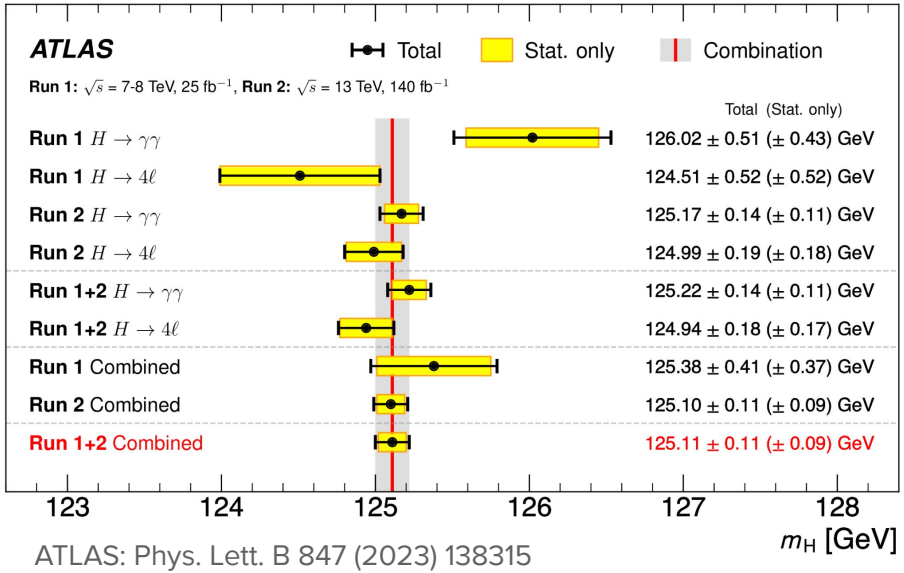
Where are we?

Higgs boson mass

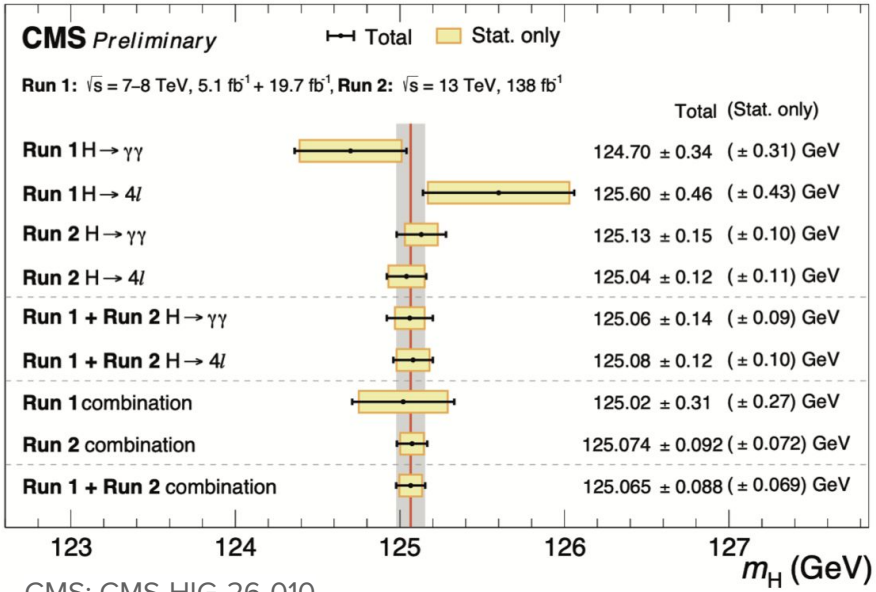
0.1% precision per experiment

for reference:
Run1 LHC combination: **125.09 ± 0.24 GeV**
Phys. Rev. Lett. 114, 191803

Higgs mass is the **only free parameter in the SM Higgs sector**.
Measured in channels with best resolution:
H→ZZ*→4l and H→γγ



ATLAS: Phys. Lett. B 847 (2023) 138315



CMS: CMS-HIG-26-010

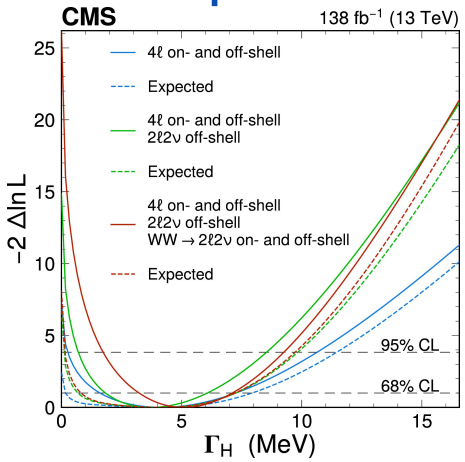
Higgs boson width

2 MeV precision per experiment

SM prediction: Γ_H = 4.07 MeV.

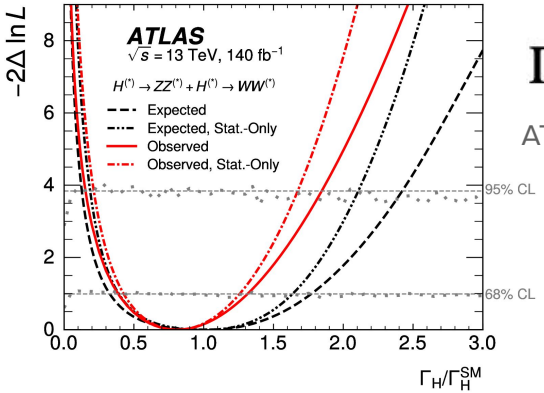
A significant excess would signal new physics.

- **Direct measurement:**
  limited by detector resolution
- **ZZ/WW:** σ(off-shell)/σ(on-shell) ∝ Γ_H, under coupling assumptions;
- **Other techniques:**
  - **ttH + four-top**
    (ATLAS:Phys. Lett. B 861 (2025) 139277)
  - **γγ interference**
    (CMS: CMS-HIG-25-004, ATLAS:HIGP-2024-12)



$$\Gamma_H = 5.1^{+2.0}_{-1.8}\,\text{MeV}$$

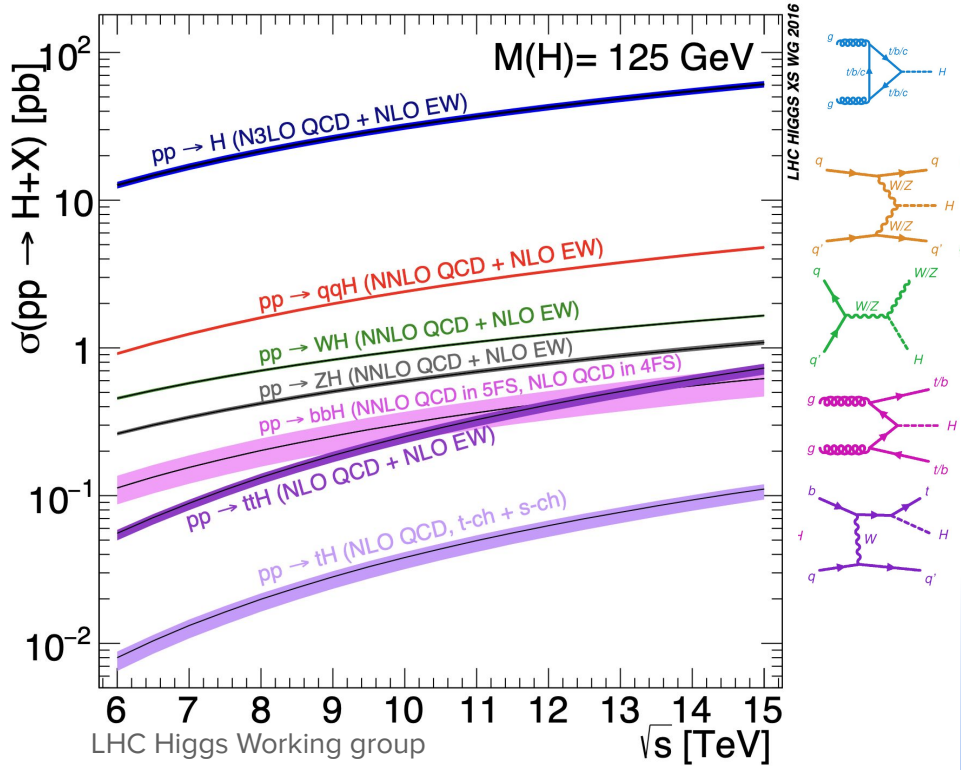
CMS: CMS-HIG-25-003

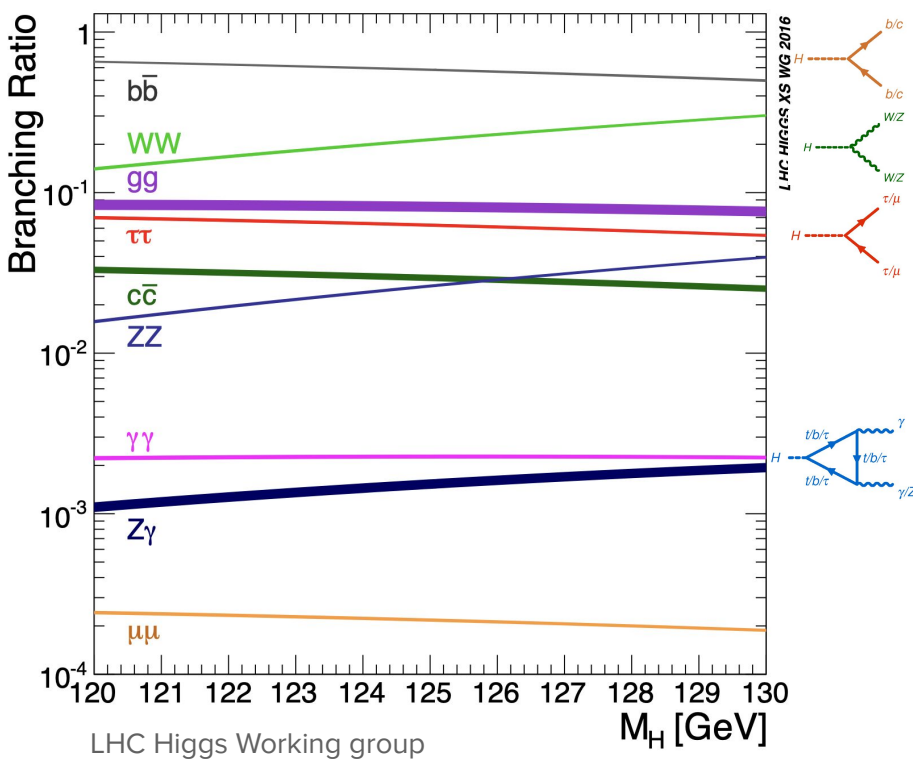


$$\Gamma_H = 3.6^{+2.1}_{-1.6}\,\text{MeV}$$

ATLAS: HIGP-2025-16

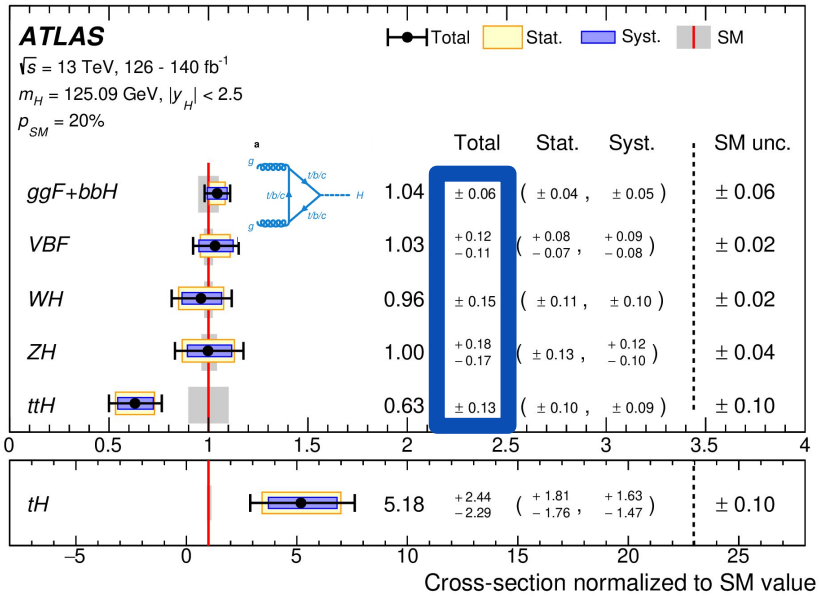
Main production modes and decay modes



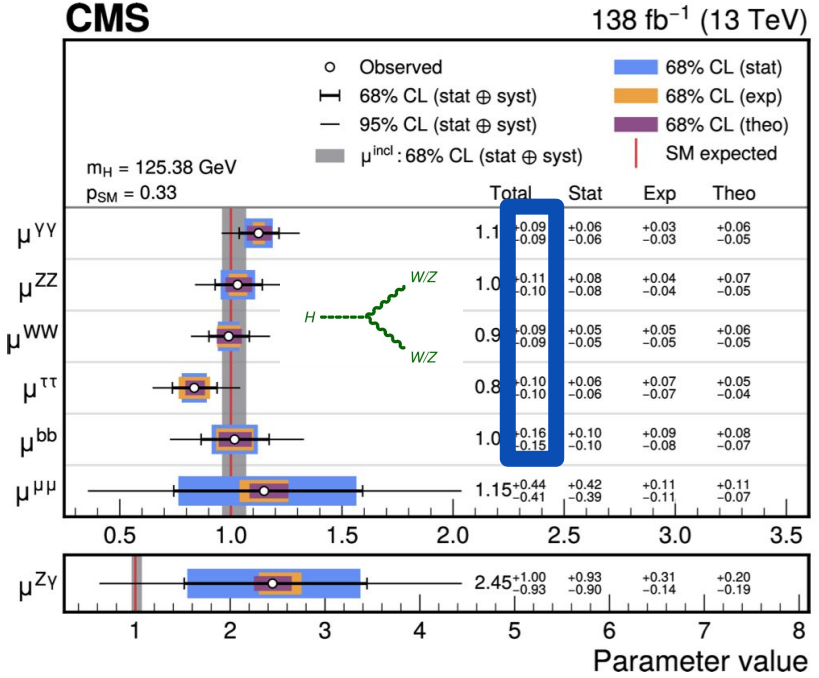


Main production and decay modes

Unprecedented precision!



ATLAS: HIGP-2025-16



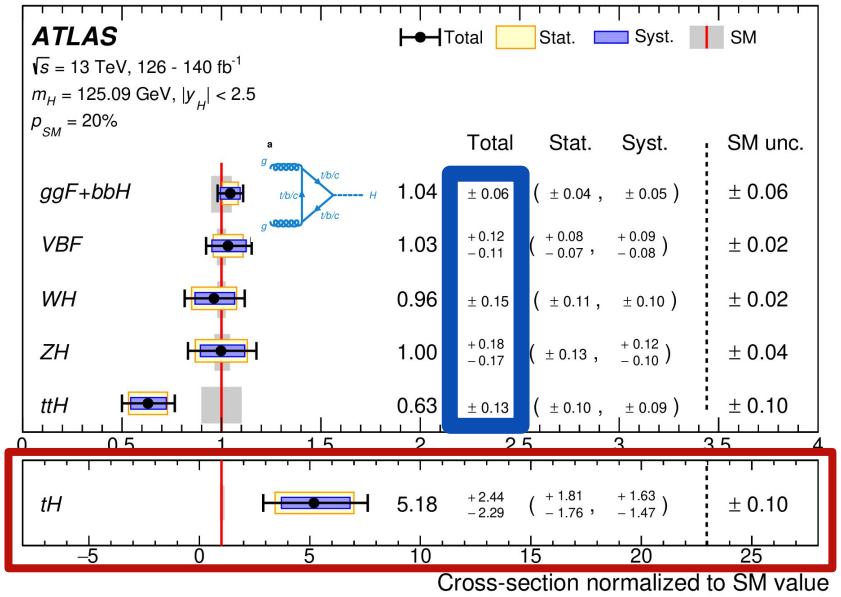
CMS: Rep. Prog. Phys. 89 (2026) 087801

All major production modes (ggF, VBF, WH, ZH, ttH)

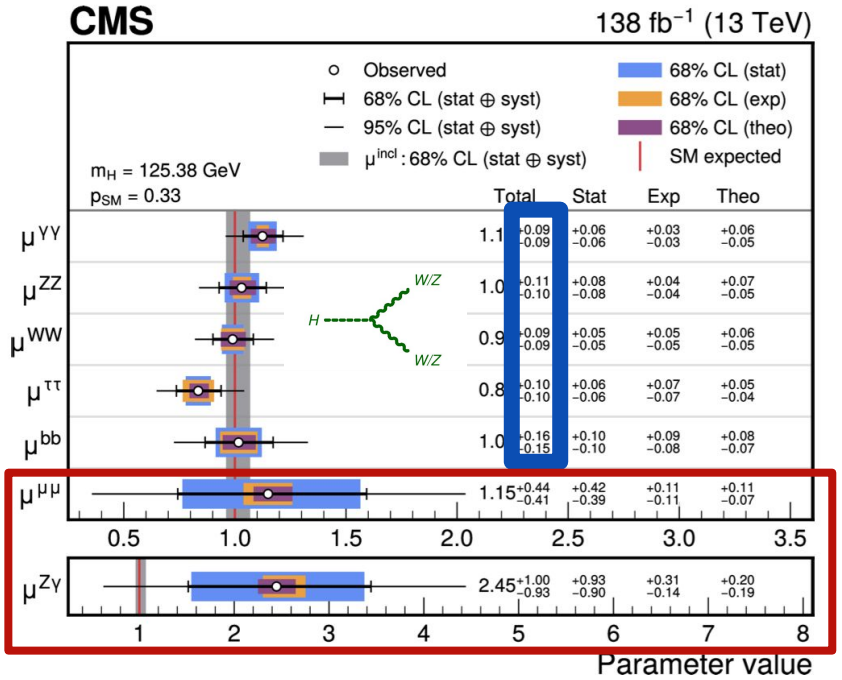
and decay modes (H→γγ, H→ZZ, H→WW, H→$\tau\tau$, H→bb) **are observed**

Main production and decay modes

Unprecedented precision!



ATLAS: HIGP-2025-16



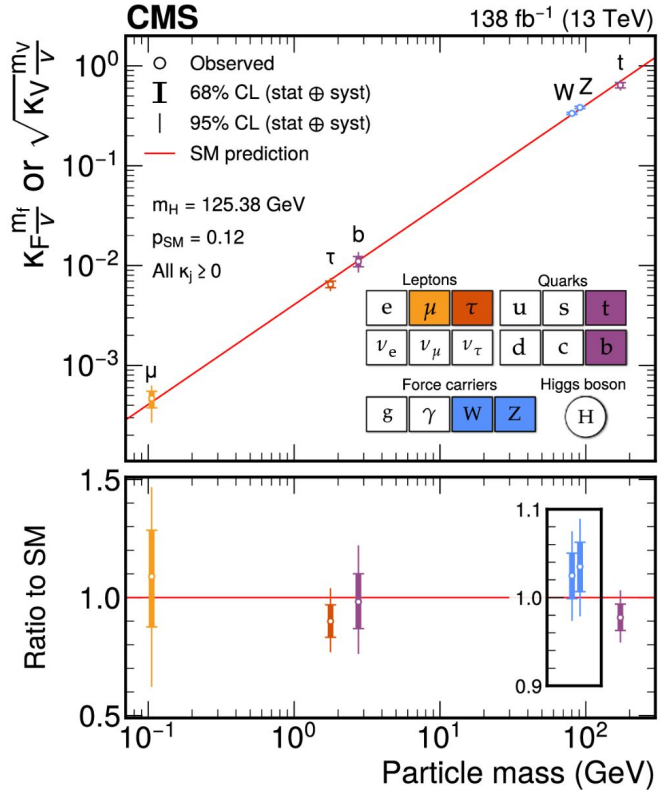
CMS: Rep. Prog. Phys. 89 (2026) 087801

The rare processes

All major production modes (ggF, VBF, WH, ZH, ttH)

and decay modes (H→γγ, H→ZZ, H→WW, H→$\tau\tau$, H→bb) **are observed**

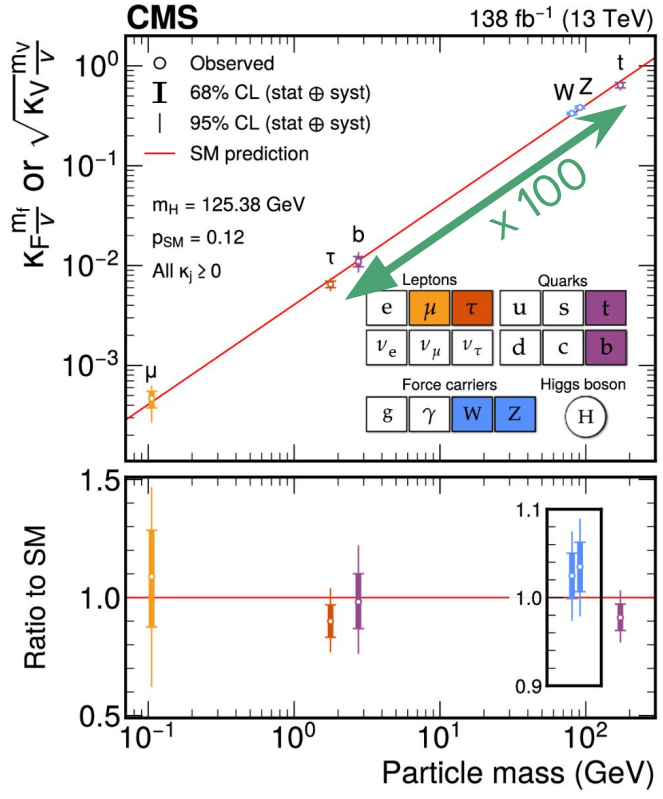
Higgs Couplings



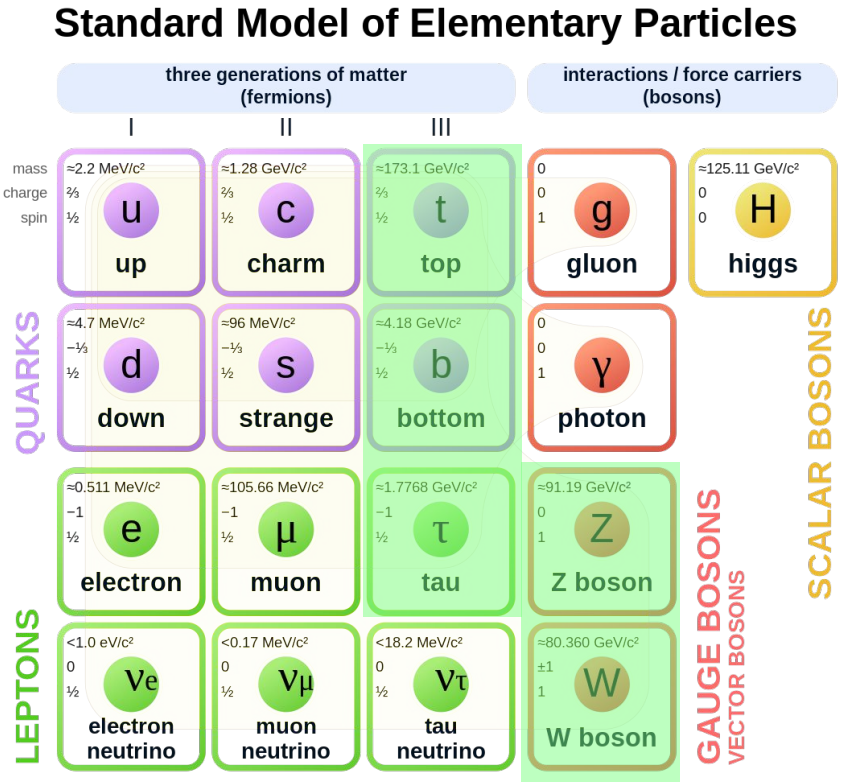
CMS: Rep. Prog. Phys. 89 (2026) 087801

Established

Higgs Couplings

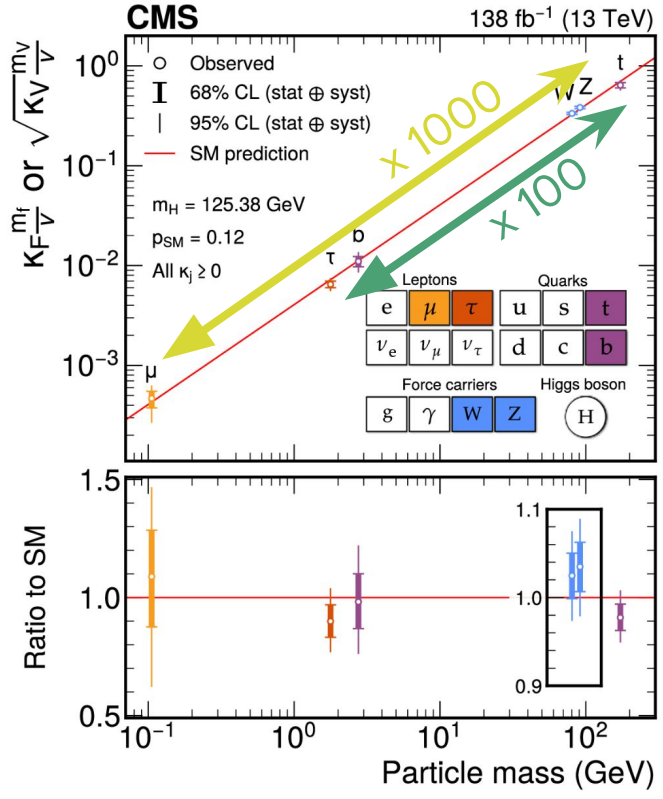


CMS: Rep. Prog. Phys. 89 (2026) 087801

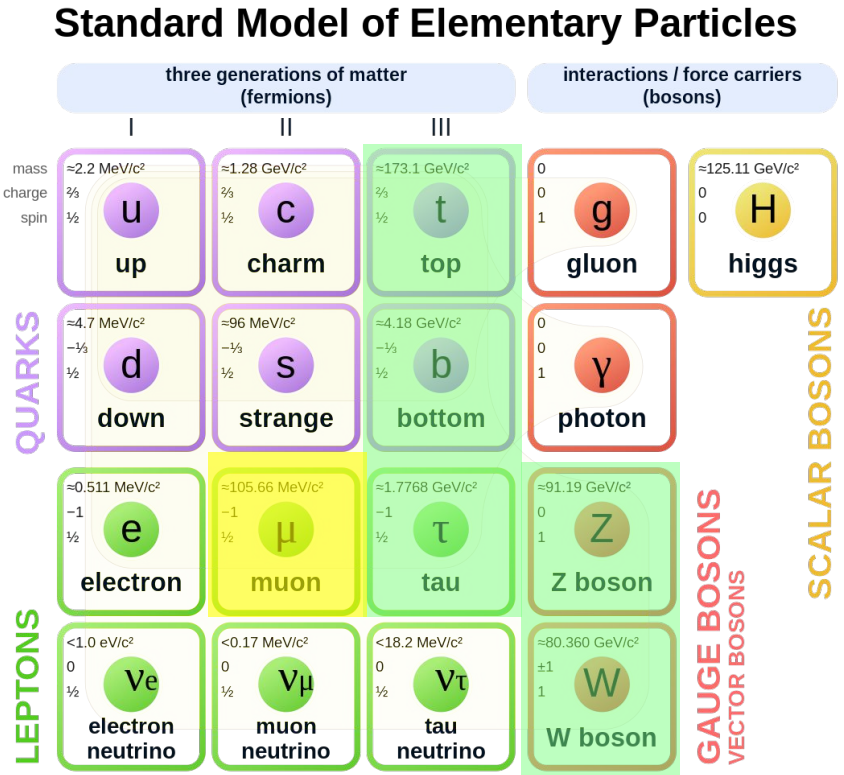


Higgs Couplings

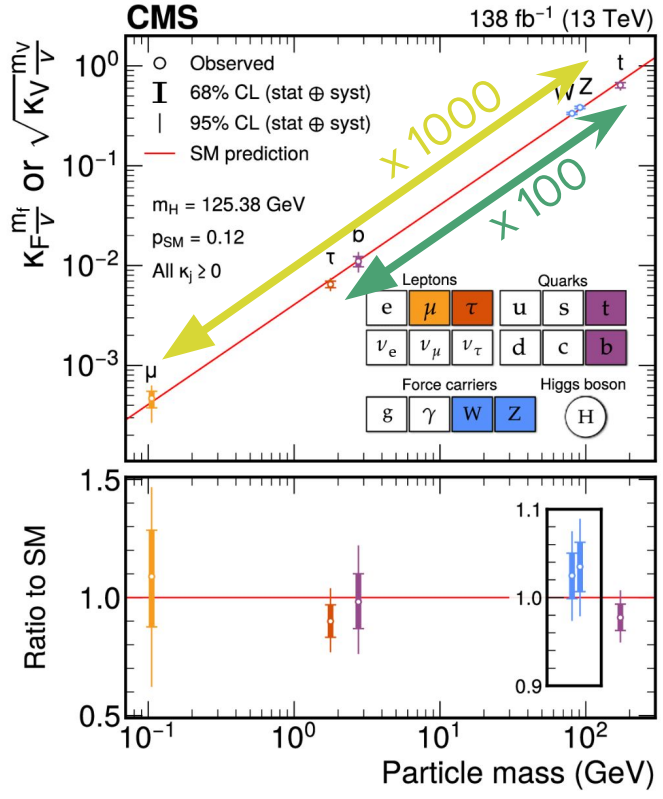
Established
First Evidences



CMS: Rep. Prog. Phys. 89 (2026) 087801

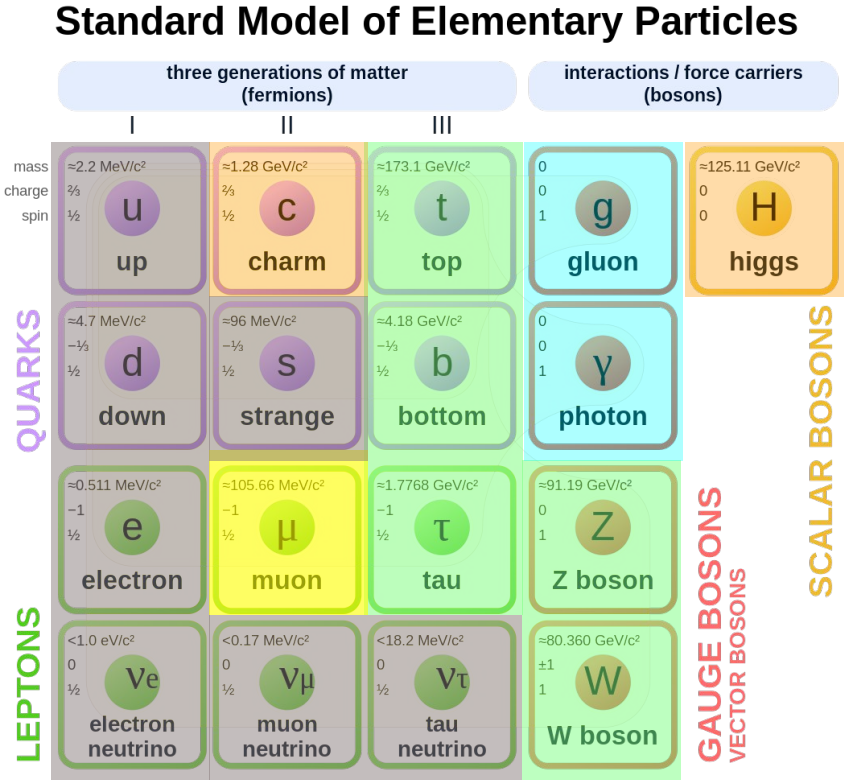


Higgs Couplings

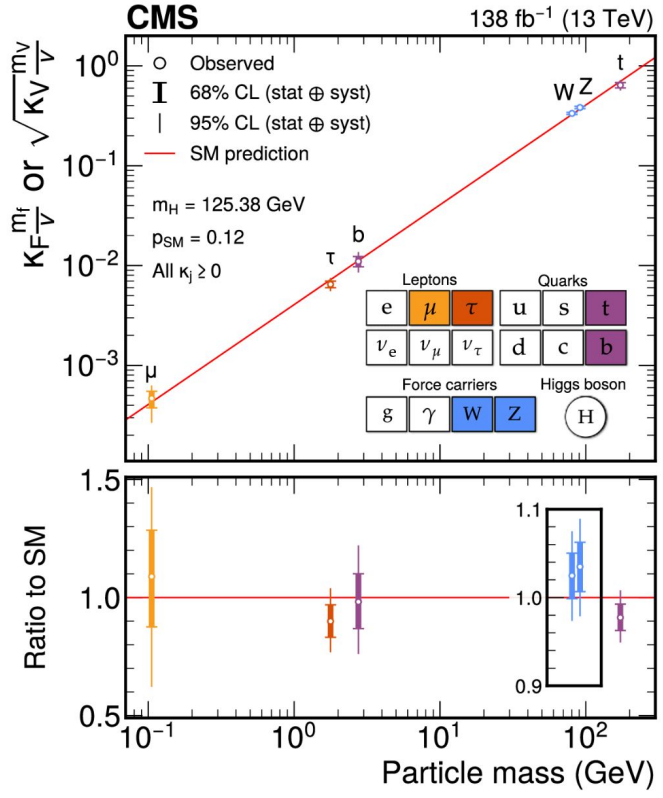


CMS: Rep. Prog. Phys. 89 (2026) 087801

Established
First Evidences
Established in loop
The LHC Challenge
No Evidence yet



Higgs Couplings



CMS: Rep. Prog. Phys. 89 (2026) 087801

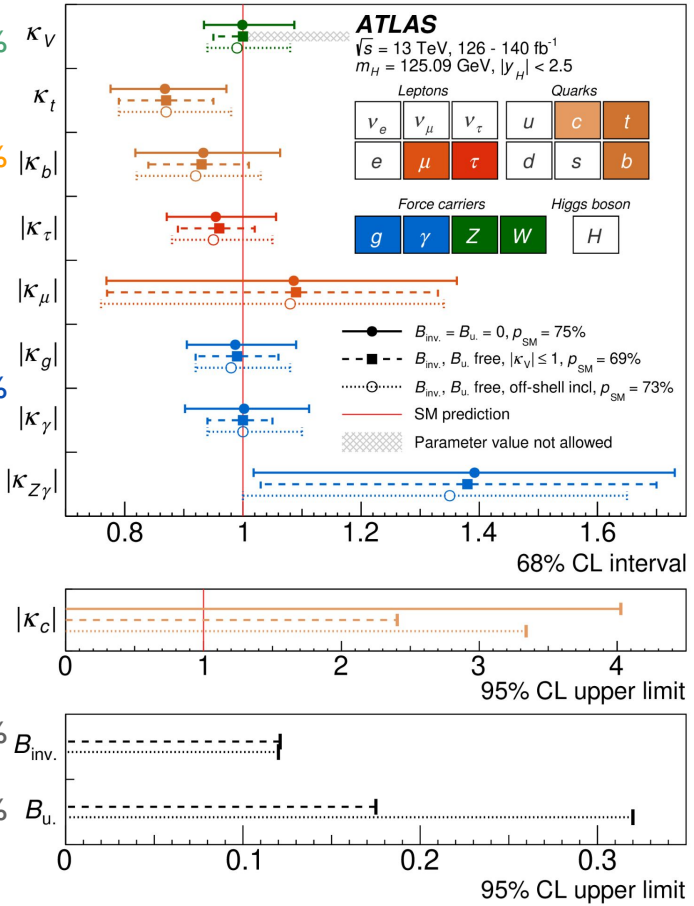
EW bosons: 5%

3rd generation fermion: 10%

Masseless bosons 6-7%

Invisible BR: < ~12%

Undetected BR< ~30%



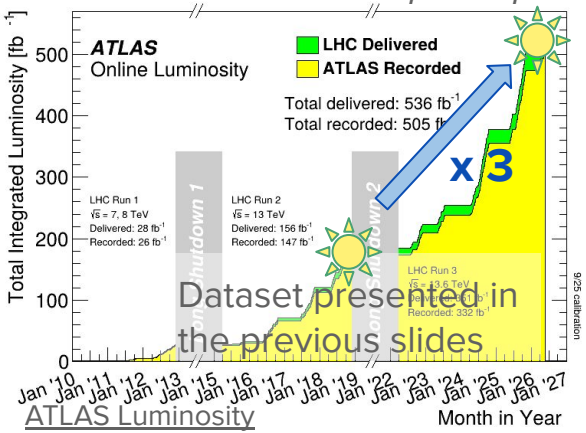
ATLAS: HIGP-2025-16

Going beyond

- Add more data
- Improve the analyses
- Look for deviations
- Explore new ideas

Add more data

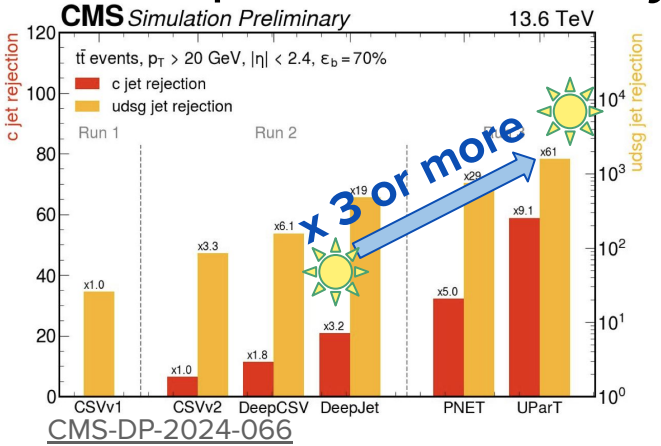
Dataset recorded per experiment



Dataset presented in the previous slides

ATLAS Luminosity

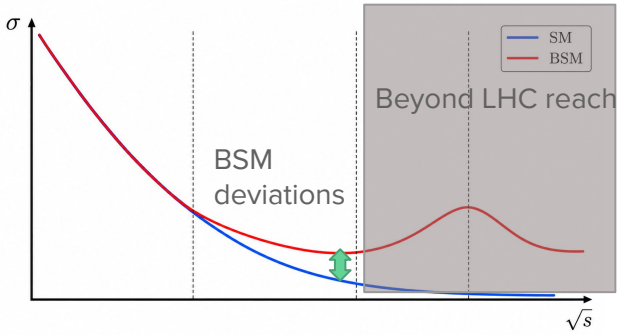
Improve the analyses



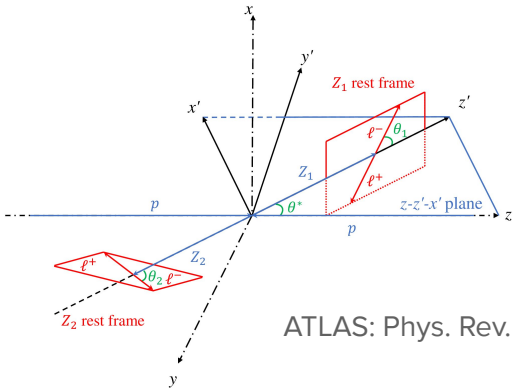
CMS-DP-2024-066

Impressive jump in object identification thanks to **advanced ML/AI techniques**

Look for deviations



Explore new ideas



Spin correlation, QE, NSBI tecniques, etc...

ATLAS: Phys. Rev. Lett. 137 (2026) 111804

Couplings to second-generation fermions: H ➔ μμ

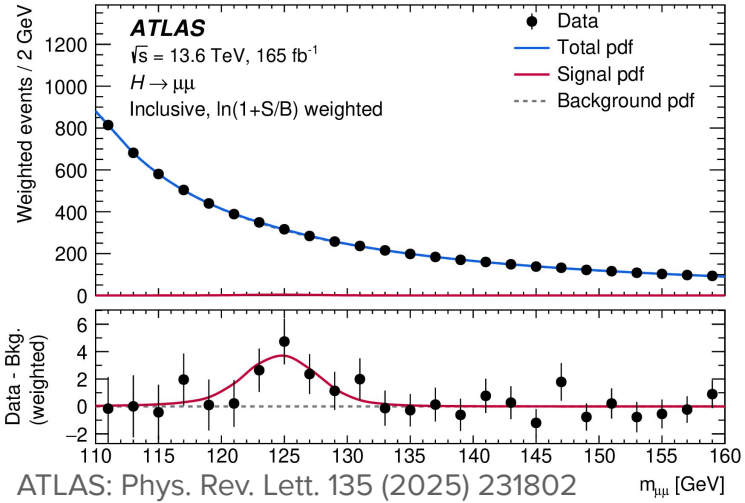
Rare decay, large background:

BR ≃ 2 × 10^{-4}, dominant Drell-Yan background (S/B ≃ 0.2%.)

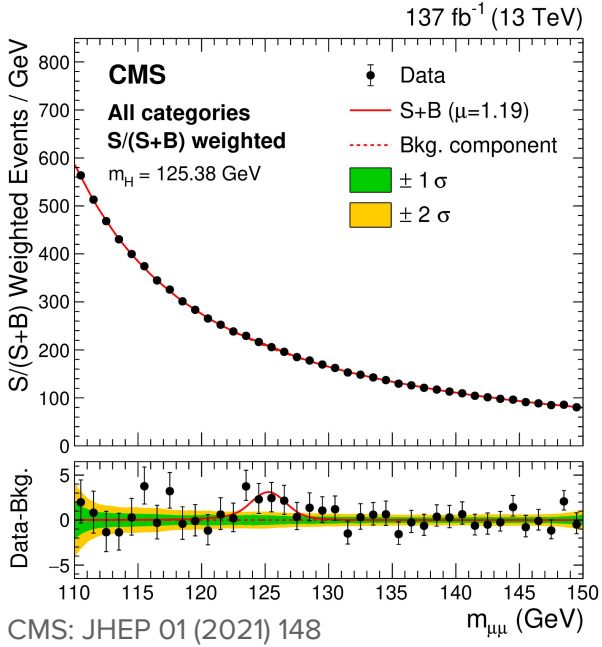
Strong evidence!
Observation within reach.
=> Higgs coupling to second-generation fermions!

ATLAS (Run 2 + part. Run 3): μ = 1.4 ± 0.4, with 3.4σ obs. (2.5σ exp.).

CMS (Run 2): μ = 1.19 (+0.40/−0.39), with 3.0σ obs. (2.5σ exp.).



ATLAS: Phys. Rev. Lett. 135 (2025) 231802



CMS: JHEP 01 (2021) 148

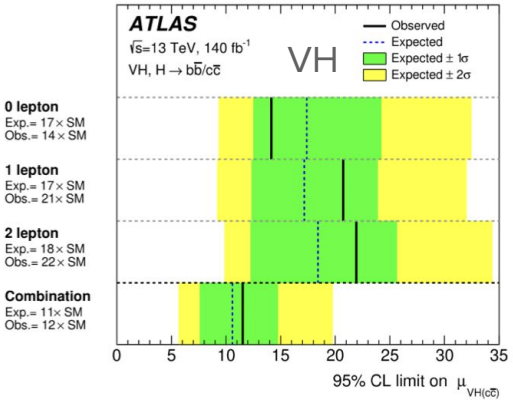
Couplings to second-generation fermions: H → cc

A major challenge:

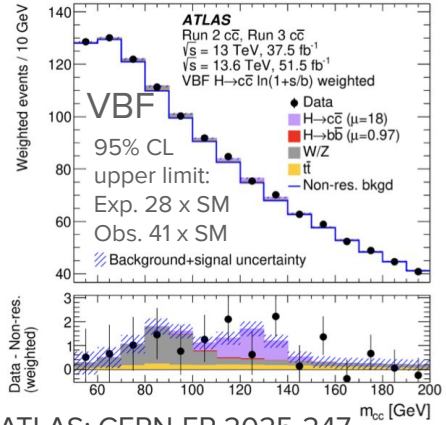
small branching fraction, large backgrounds, and difficult separation of charm jets from bottom and light-flavour jets.

How to improve sensitivity:

- Extend **searches beyond VH to ttH and VBF** production.
- **Improve charm tagging** and rejection of bottom and light-flavour jets.
- Explore Higgs production in association with charm (**H + charm**).

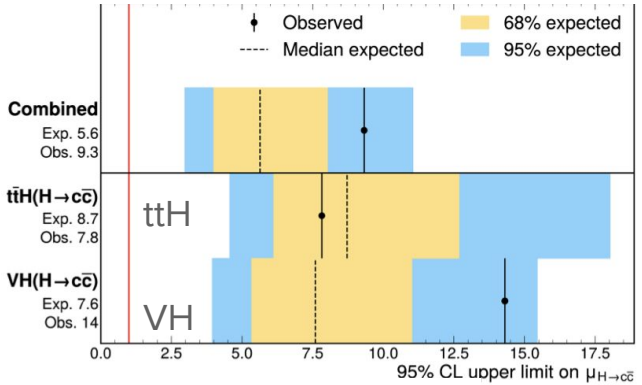


ATLAS: JHEP 04 (2025) 075



ATLAS: CERN-EP-2025-247

$|\kappa_c| < 3.5$ (2.7)



CMS: Phys. Rev. Lett. **136**, 011801

Couplings to second-generation fermions: H → cc

A major c

small bran

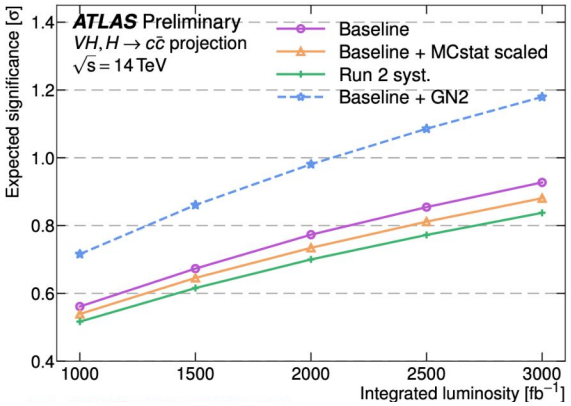
light-flavo

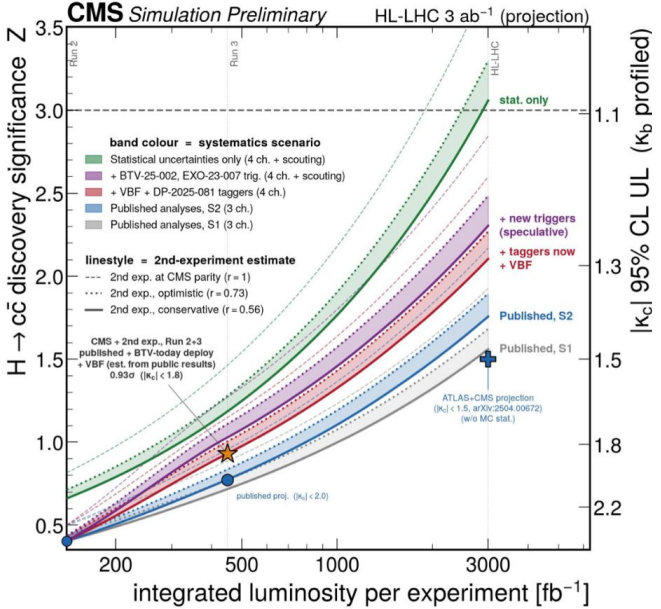
How to im

- Exte
- **Impr**
- Expl

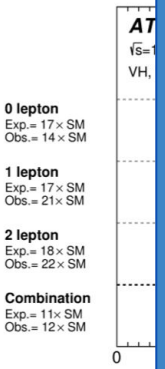
HL-LHC Projections

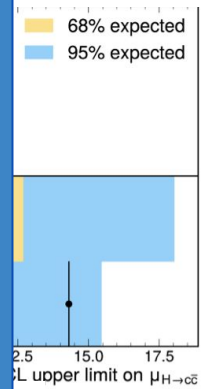
Both collaborations have produced **projections for H → cc**, and the impact of **technological developments needed**





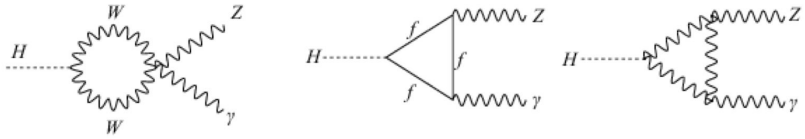
ATLAS: ATL-PHYS-PUB-2025-012





H → Zγ: Probing loop-induced Higgs couplings

Rare decay loop-suppressed in the SM with BR = 1.5 × 10^{-3} → Sensitive to BSM effects

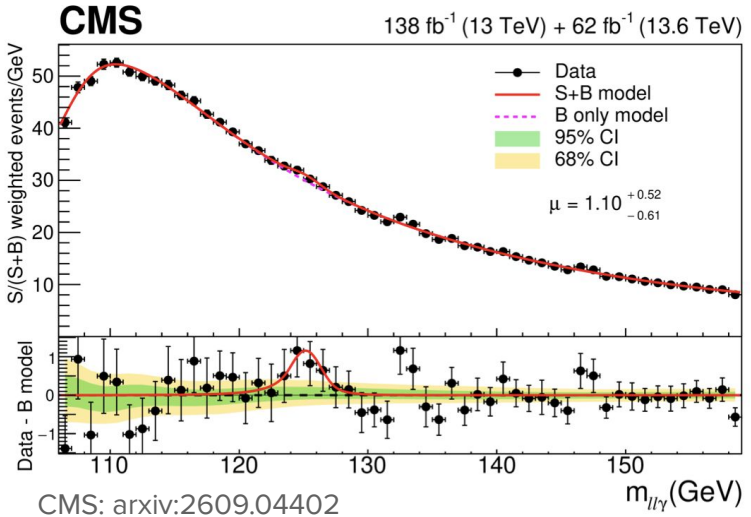


Intriguing ATLAS+CMS in Run 2 :
μ(σ/σ_SM) = 2.2 ± 0.7
(Obs./Exp. 3.4/1.6σ - about 2σ above SM prediction)
(Phys. Rev. Lett. 132 (2024) 021803)

CMS (Run 2+ partial Run 3 (62ifb):
μ = 1.1 (+0.5/−0.6), with 1.9σ obs. (2.3σ exp.).
CMS: arxiv:2609.04402

ATLAS (Run 2 + partial Run 3 (146ifb)):
μ = 1.3 (+0.6/−0.5), with 2.5σ obs. (1.9σ exp.)
ATLAS: Phys. Lett. B 876 (2026) 140313

Approaching the single experiment evidence



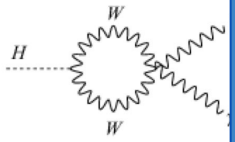
CMS: arxiv:2609.04402

Evidence for H→ γγ* CERN-EP-2026-223

ATLAS (Run 2 + partial Run 3 (146ifb)):
μ = 1.03 (+0.35/−0.32), with 3.4σ obs. (3.3σ exp.).

H → Zγ: Probing loop-induced Higgs couplings

Rare decay lo
BR = 1.5 × 10^{-3}



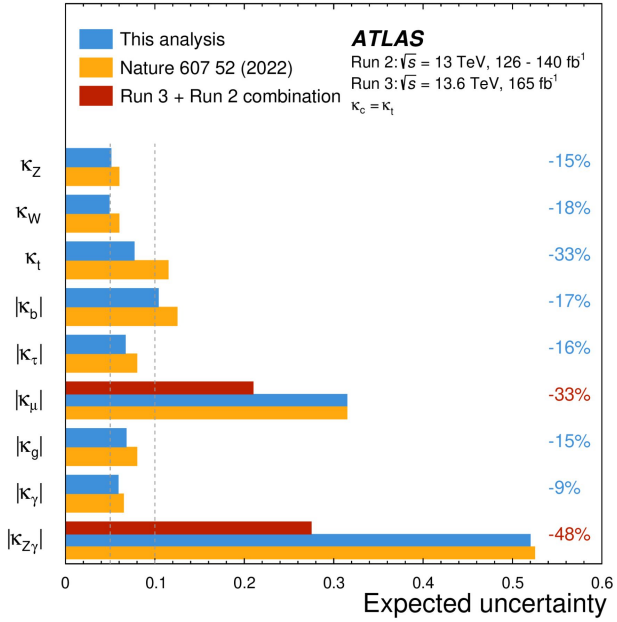
Intriguing ATL
μ(σ/σ_SM) = 2.
(Obs./Exp. 3.4/
(Phys. Rev. Lett. 132

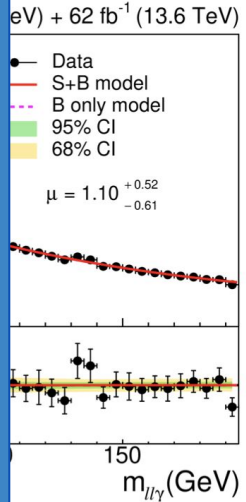
CMS (Run 2+ μ
μ = 1.1 (+0.5/−0
CMS: arxiv:2609.04

ATLAS (Run 2
μ = 1.3 (+0.6/−0
ATLAS: Phys. Lett. B

Impact of adding partial Run 3 data

Partial Run 3
H → Zγ and **H → μμ**
improve Run 2 couplings
by 30–50%.





2026-223

3σ exp.).

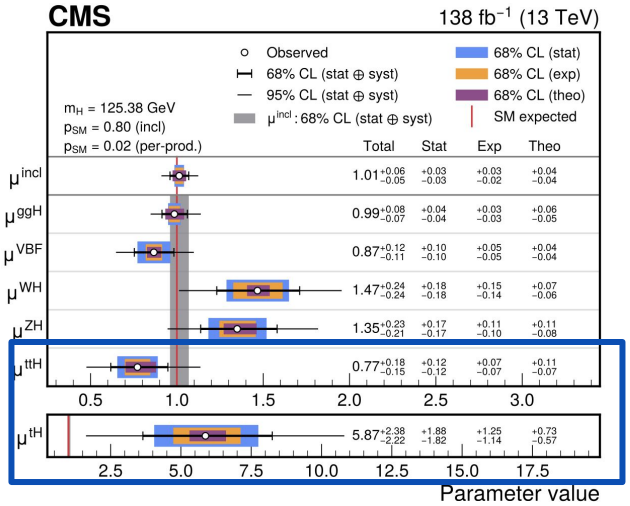
Rare productions: tH

Mild excess in tH, a rare production mechanism!

ttH and **tH** probe the top Yukawa coupling, **the largest Yukawa coupling in the SM.**

Run 2: mild deviations, with a **small excess in tH production**.

Significant deviations could signal BSM physics, potentially including CP violation.



CMS: Rep. Prog. Phys. 89 (2026) 087801

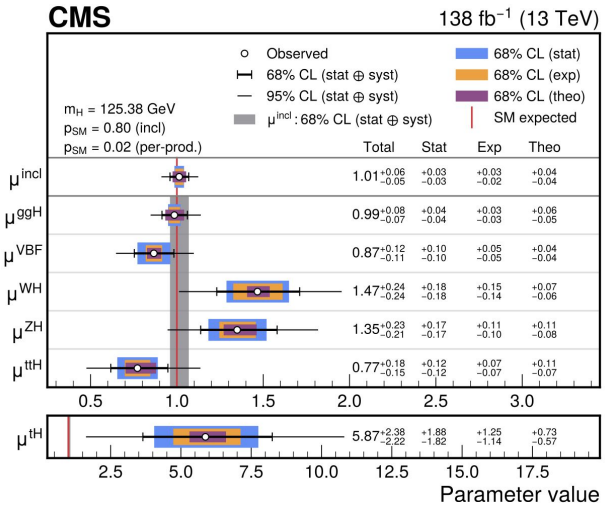
Rare productions: tH

Mild excess in tH, a rare production mechanism!

ttH and **tH** probe the top Yukawa coupling, **the largest Yukawa coupling in the SM.**

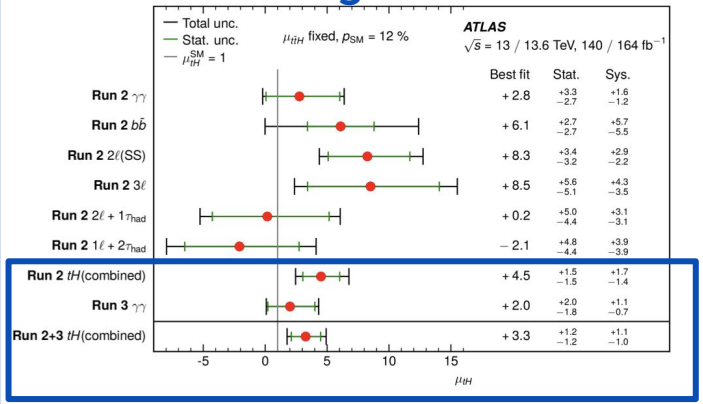
Run 2: mild deviations, with a **small excess in tH production**.

Significant deviations could signal BSM physics, potentially including CP violation.

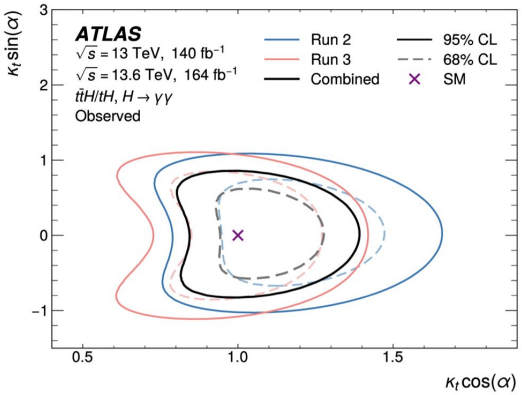


CMS: Rep. Prog. Phys. 89 (2026) 087801

Using Run3 data



ATLAS: arXiv:2607.27708



ATLAS:arXiv:2606.04855

Mild excess for tH [2.3σ obs.(0.8σ exp.).

No Strong indication for CP violation (yet?)

Higgs and CP violation

Sakharov conditions for a matter-dominated universe require CP violation

CP violation in Higgs sector?

- Possible in some models with extended Higgs sector

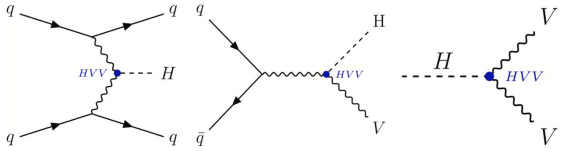
Higgs and CP violation

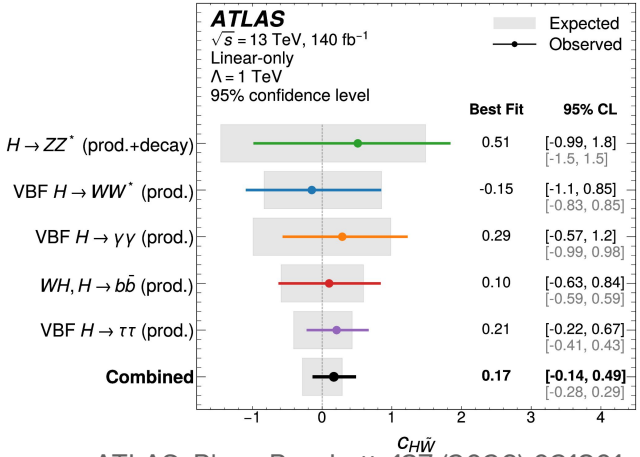
Sakharov conditions for a matter-dominated universe require CP violation

CP violation in Higgs sector?

- Possible in some models with extended Higgs sector

CP violation in HVV interaction





No indication of CP violation in HVV (yet?)

ATLAS: Phys. Rev. Lett. 137 (2026) 021801

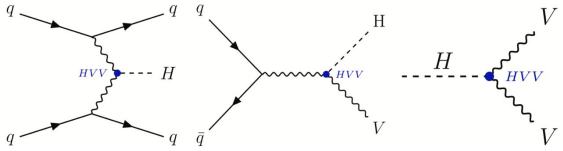
Higgs and CP violation

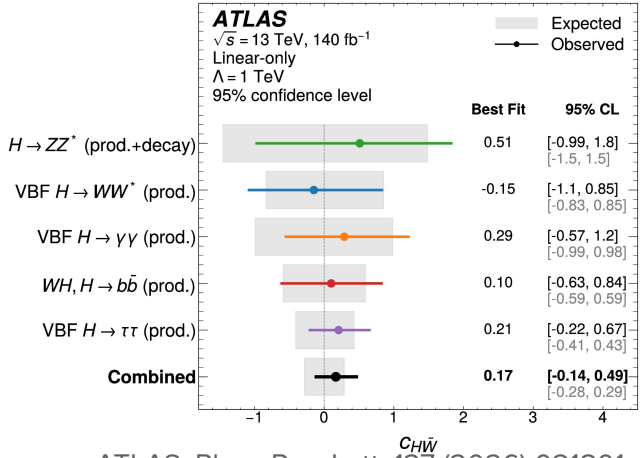
Sakharov conditions for a matter-dominated universe require CP violation

CP violation in Higgs sector?

- Possible in some models with extended Higgs sector

CP violation in HVV interaction

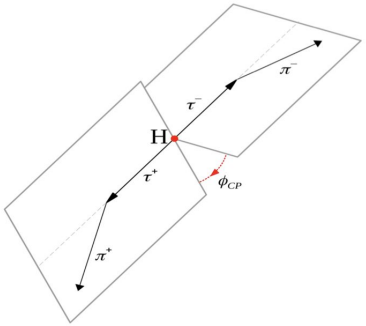


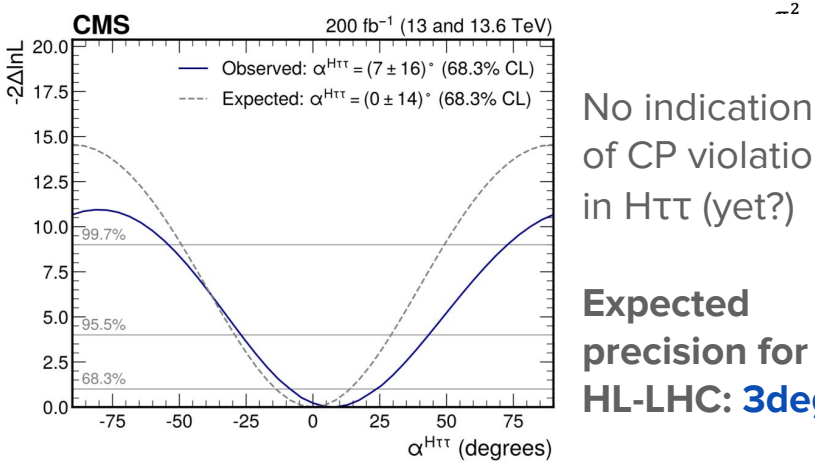


No indication of CP violation in HVV (yet?)

ATLAS: Phys. Rev. Lett. 137 (2026) 021801

CP violation in H→ ττ Decay





No indication of CP violation in Hττ (yet?)

Expected precision for HL-LHC: 3deg

CMS: arXiv:2606.03510

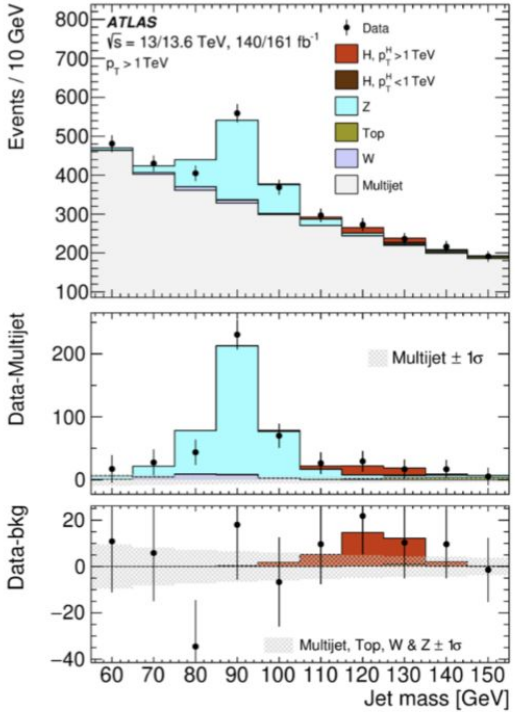
Higgs boson in the high transverse momentum regime

High p_T enhances **sensitivity to BSM**

Dedicated object reconstruction is essential.

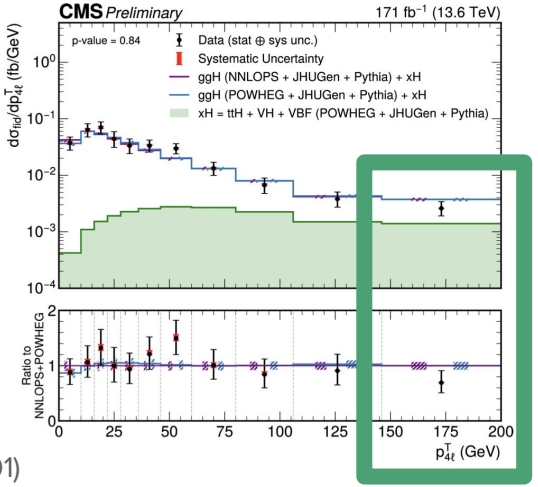
New results: Run 2 + partial Run 3

- **H → ττ:** evidence for $p_T > 350$ GeV
  (ATLAS: HIGP-2024-49)
- **H → bb̄:** evidence for $p_T > 450$ GeV
  Measurements for $p_T > 1$ TeV
  (ATLAS: Phys. Rev. Lett. 137 (2026) 071801)



(ATLAS: Phys. Rev. Lett. 137 (2026) 071801)

A complementary extension to precision differential measurements



CMS: CMS-PAS-HIG-25-015

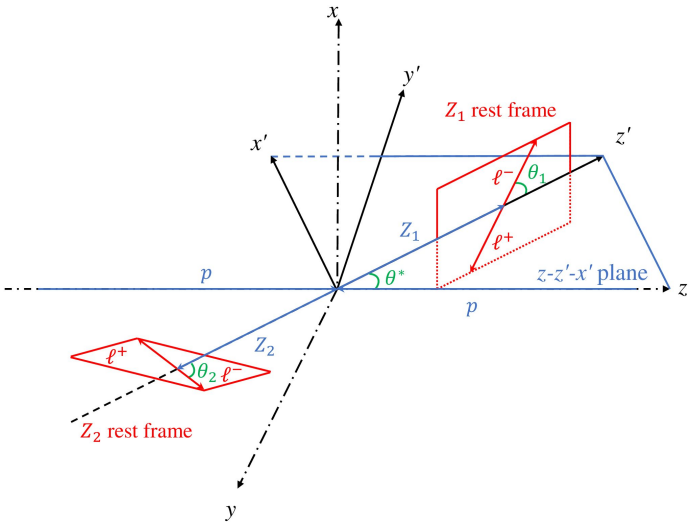
Quantum Entanglement and the Higgs boson

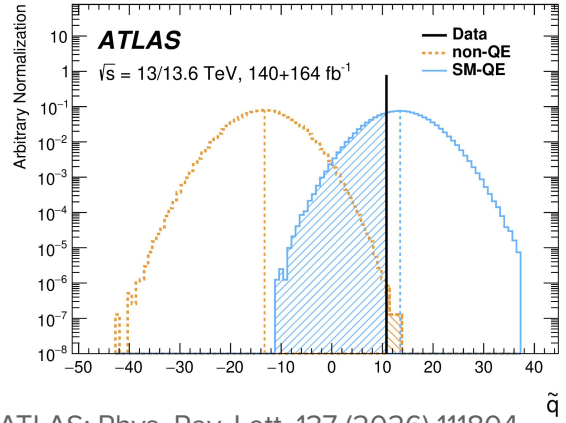
New approach:
use the Higgs decay products to probe quantum entanglement:

quantum entanglement **between spins in pairs of Z bosons** produced in the **Higgs decay.**

This is achieved by measuring **angular observables** sensitive to **spin-density-matrix elements**, by both ATLAS and CMS

The angular analysis provides
4.7σ evidence for entanglement
between massive bosons, under SM decay assumptions.





ATLAS: Phys. Rev. Lett. 137 (2026) 111804

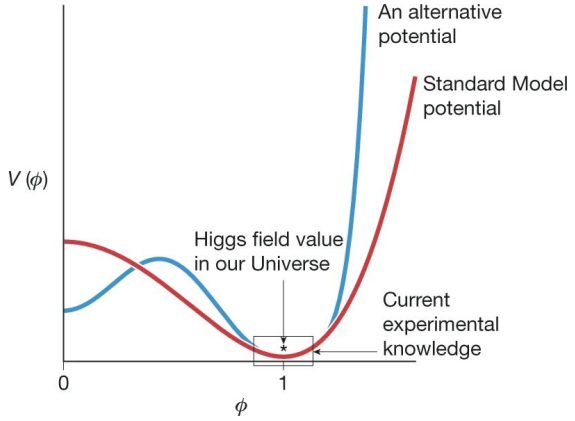
The Higgs potential

Higgs Self Coupling

Determines the shape of the potential

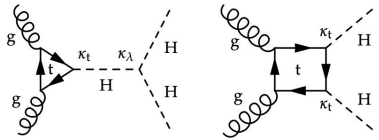
Key to understand EW phase transition and vacuum stability

Salam, G.P., Wang, LT. & Zanderighi, G.
The Higgs boson turns ten.
Nature **607**, 41–47 (2022)



Destructive interference in H-top and H self-coupling

- **cross section of HH/H is 1/1000**

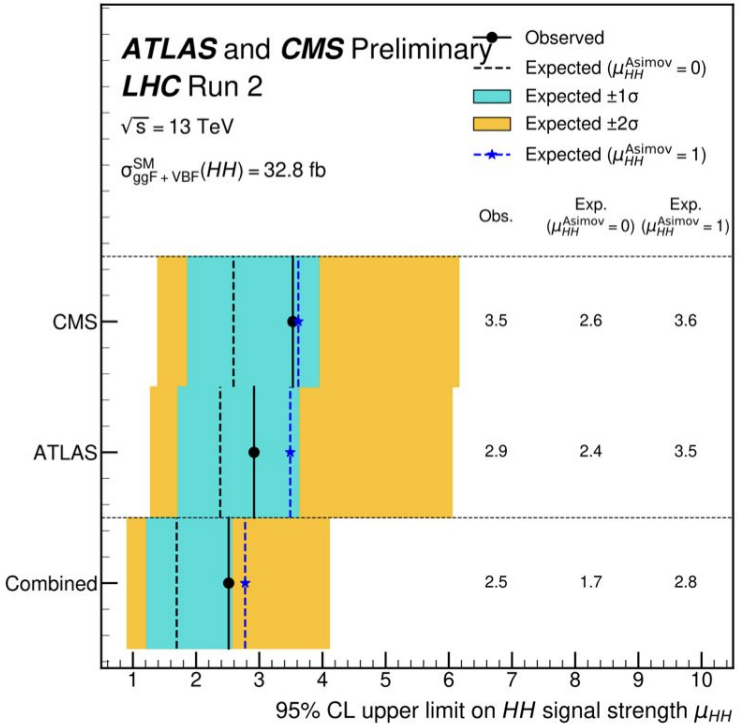


ATLAS+CMS Run2 Combination

$\mu = 0.8(+0.9-0.7)$, $\mu < 2.5$

Significance: 1.1σ

$-0.7 < \kappa_\lambda < 6.1$



ATLAS+CMS: Phys. Rev. Lett. 137 (2026) 131803

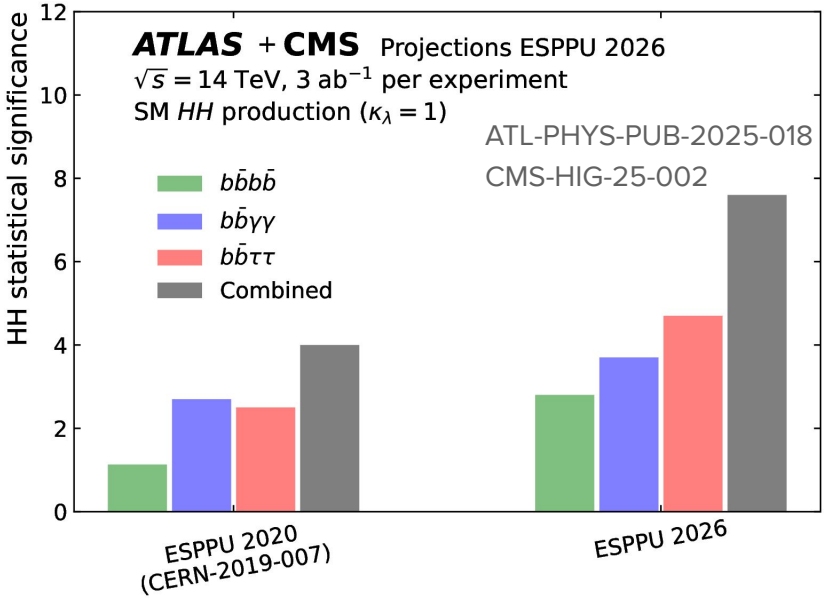
Higgs Self Couplings: HL-LHC projections

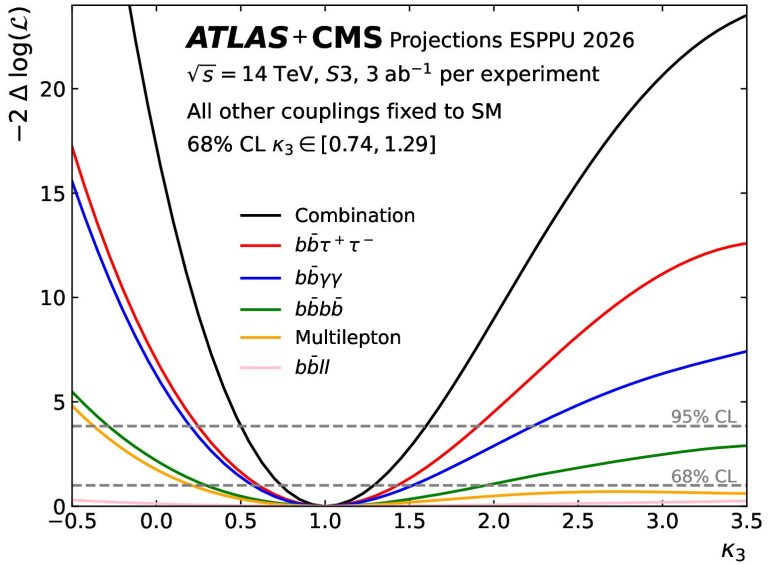
European Strategy for Particle Physics Update (ESPPU) projections based on Run2 results.

Observation of HH in single experiment at 3 ab-1

5σ on non-zero κ_λ at 3 ab-1 combining ATLAS+CMS

30% precision on κ_λ





ATL-PHYS-PUB-2025-018
CMS-HIG-25-002

Can we do better?

Double Higgs Run3 results - Just an example!

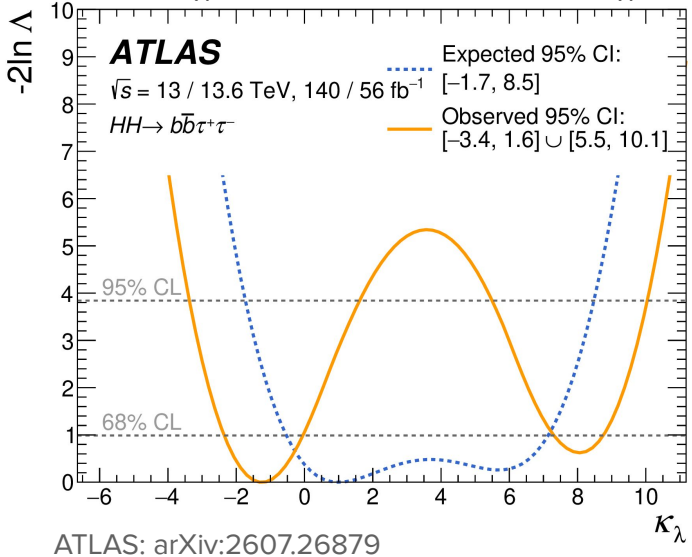
ATLAS HH→ 2b2τ, 196 fb-1

40% improvement to Run2 lumi scaling

μ = 2.6 (+1.4−1.0), μ < 5.3(2.4)

Obs. (exp.) significance: 2.6 (1.2) σ

Obs. (exp.) κ_λ in [-3.4,1.6] [5.5, 10.1] (κ_λ in [-1.7,8.5])



ATLAS: arXiv:2607.26879

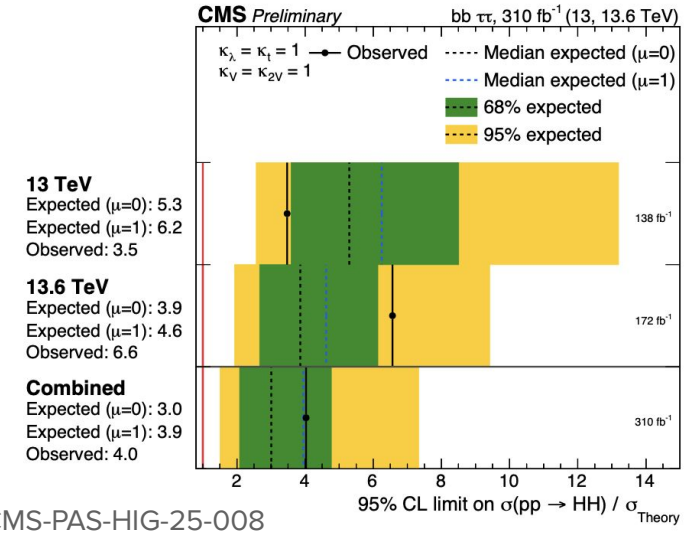
CMS HH→ 2b2τ, 310 fb-1

20% improvement to Run2 lumi scaling

μ = 1.1 (+1.5−1.3), μ < 4.0(3.0)

Obs. (exp.) significance: 0.7 (0.8) σ

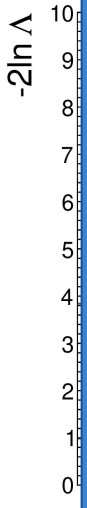
Obs. (exp.) κ_λ in [-2.5,9.5] (κ_λ in [-1.5,8.3])



CMS: CMS-PAS-HIG-25-008

Double Higgs Run3 results - Just an example!

ATLAS
40% i
μ = 2.6
Obs. (
Obs. (



ATLAS: arXiv:2607.26879

CMS: CMS-PAS-HIG-25-008

Double Higgs and self coupling

Main channels updated by both **ATLAS (2b2γ, 2b2τ)** and **CMS (4b, 2b2γ, 2b2τ, 2b2W,2W2Z)** using **partial Run3 data**.

Impressive work on object and analysis optimisation is delivering **improvements of 20–40% in each of the main channels.**

The **3σ evidence threshold**, considered beyond the reach of Run 3 just a few years ago - or achievable only through an ATLAS+CMS combination - now **looks increasingly attainable!**

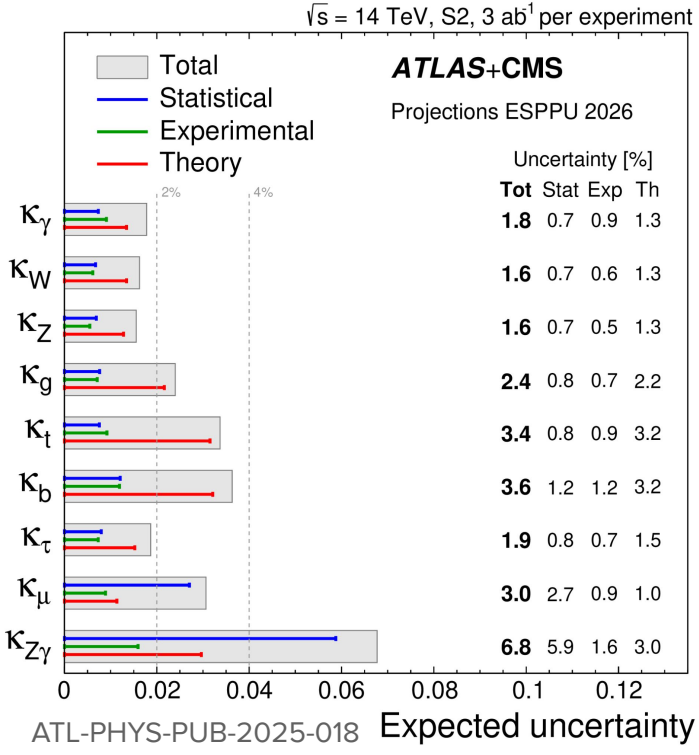
Exciting surprises lie ahead!

Conclusions

- **From discovery to precision:** remarkable progress in measuring Higgs properties and interactions.
- **Fundamental questions remain:** probing the Higgs potential and self-interaction is a crucial next step.
- **Run 3, HL-LHC and Future colliders:** sharper tests of the Standard Model and new opportunities to reveal deviations.
  - HL-LHC results will provide key inputs for higher-precision measurements at future colliders.

Precision Higgs physics will deepen our understanding...

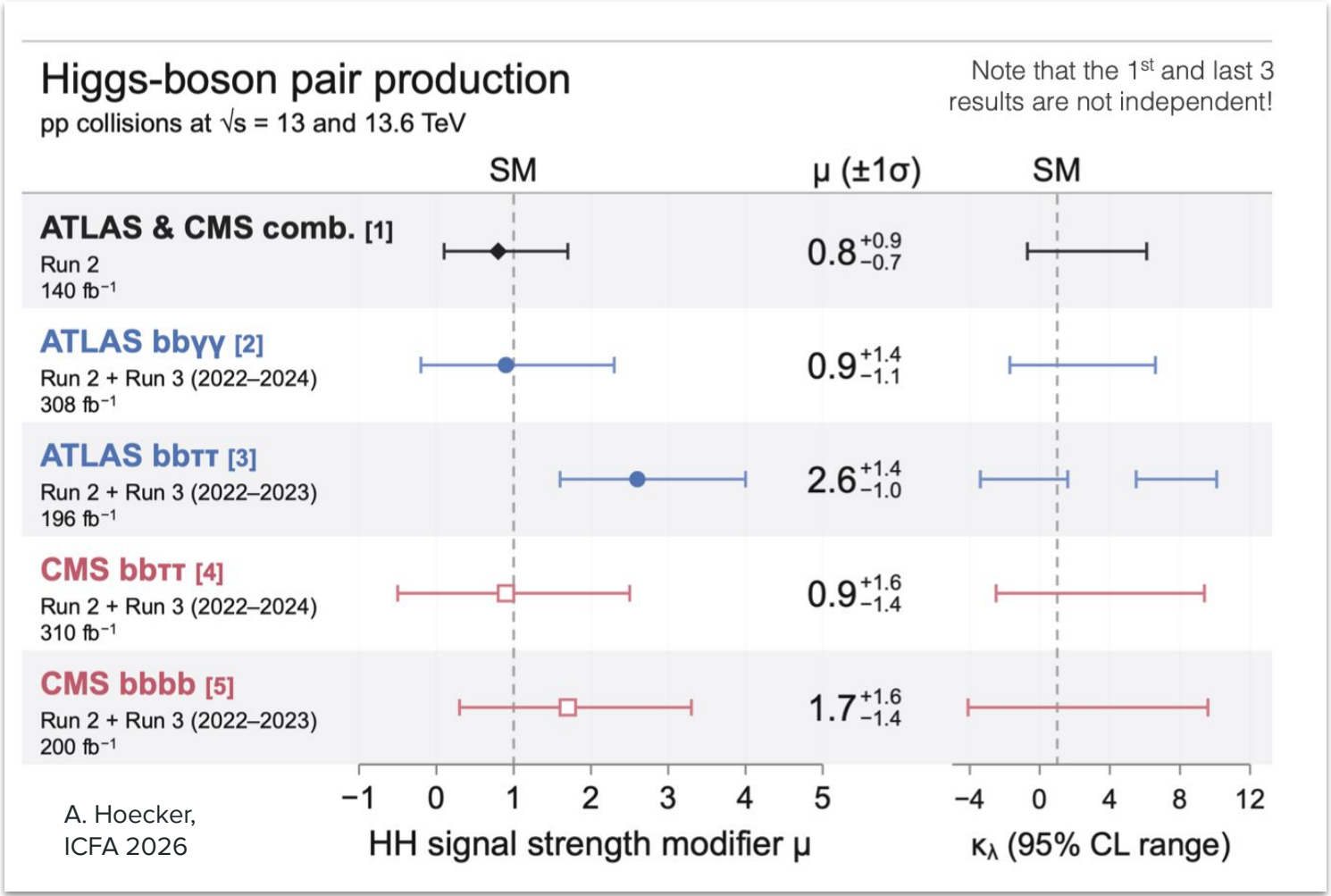
...and could reveal what lies beyond the Standard Model.



ATL-PHYS-PUB-2025-018
CMS-HIG-25-002

Backup

κ_λ intervals



A. Hoecker,
ICFA 2026

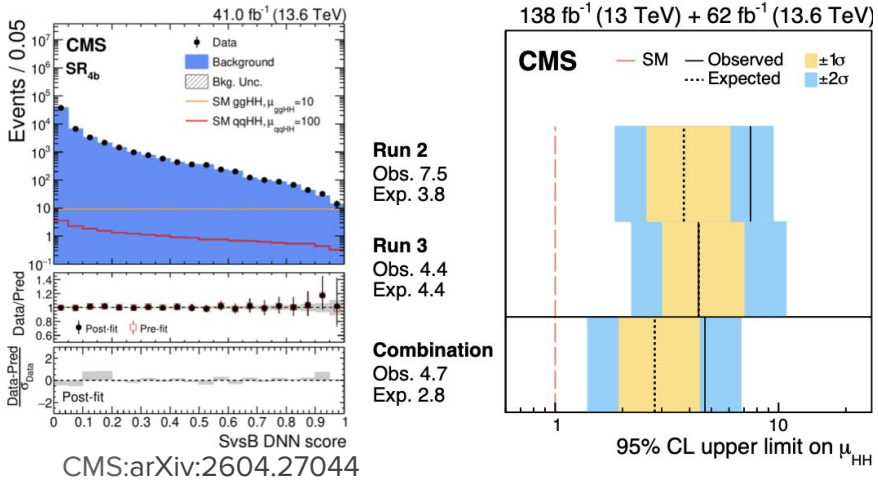
HH Run3 results

CMS HH→ 4b, 200 fb-1

30% improvement to Run2 lumi scaling

μ = 1.7(+1.6−1.4), μ < 4.7(2.8)

Significance: 1.3 σ



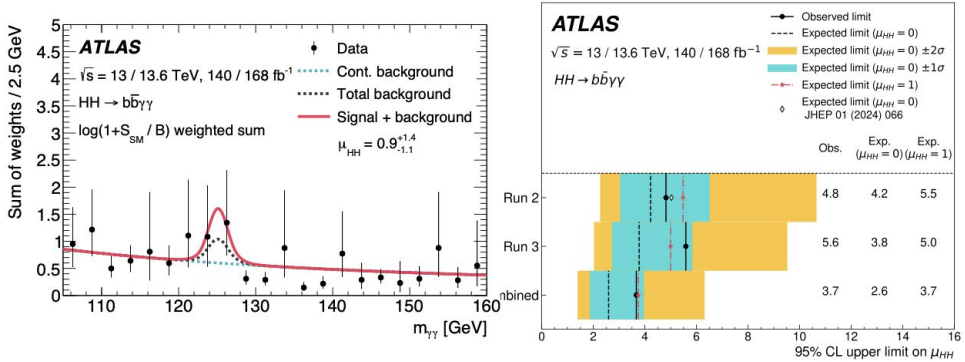
CMS:arXiv:2604.27044

ATLAS HH→ 2b2γ, 308 fb-1

25% improvement to Run2 lumi scaling

μ = 0.9(+1.4−1.1), μ < 3.7(2.6)

Significance: 0.9 σ

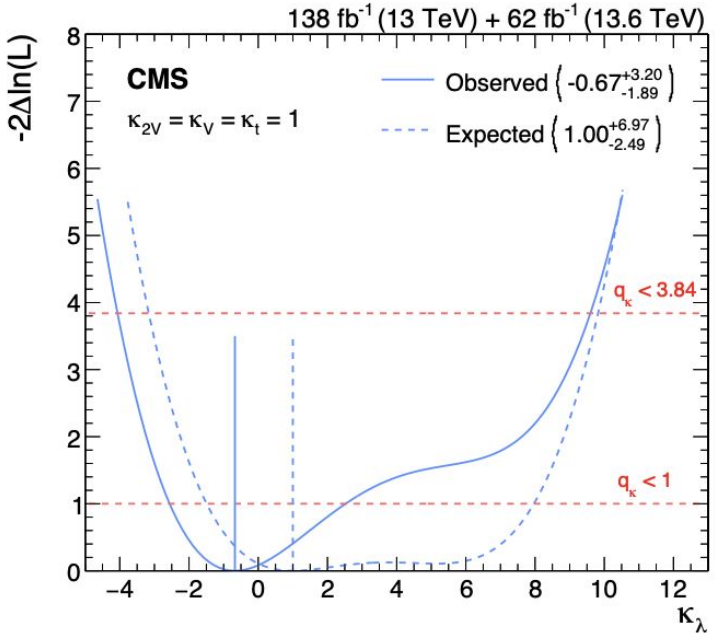


ATLAS:Phys. Lett. B 876 (2026) 140280

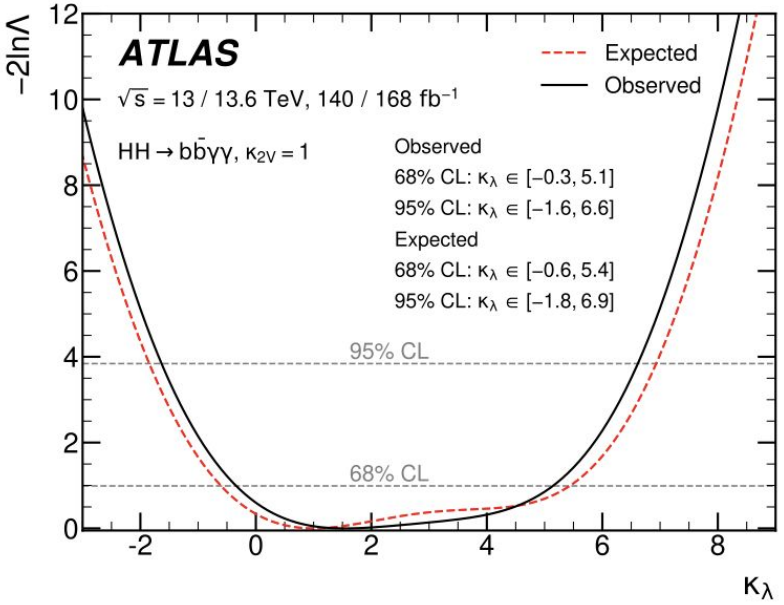
CMS HH→ 2b2γ Run3 result: CMS-PAS-HIG-25-007

LH Scans κ_λ

CMS HH→ 4b, 200 fb-1

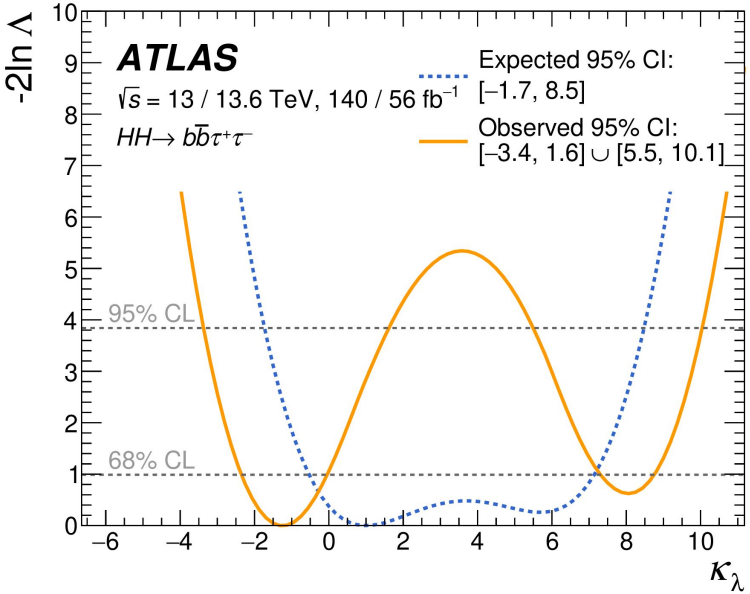


ATLAS HH→ 2b2γ, 308 fb-1

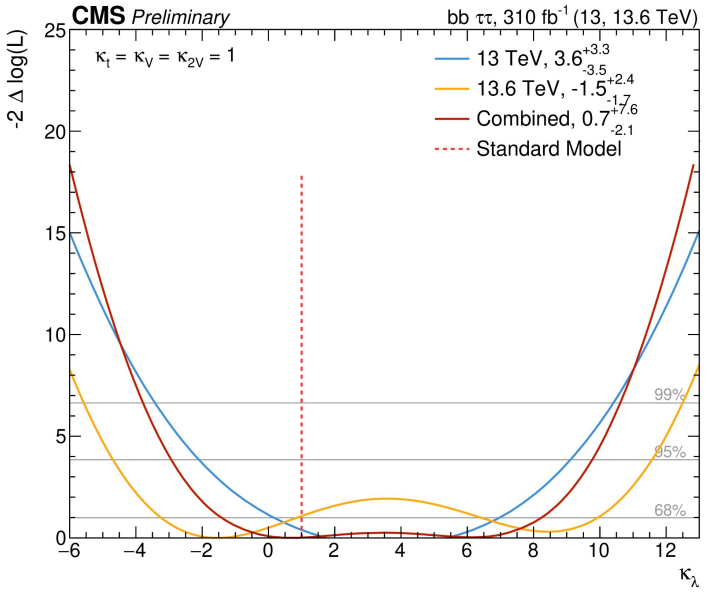


LH Scans κ_λ

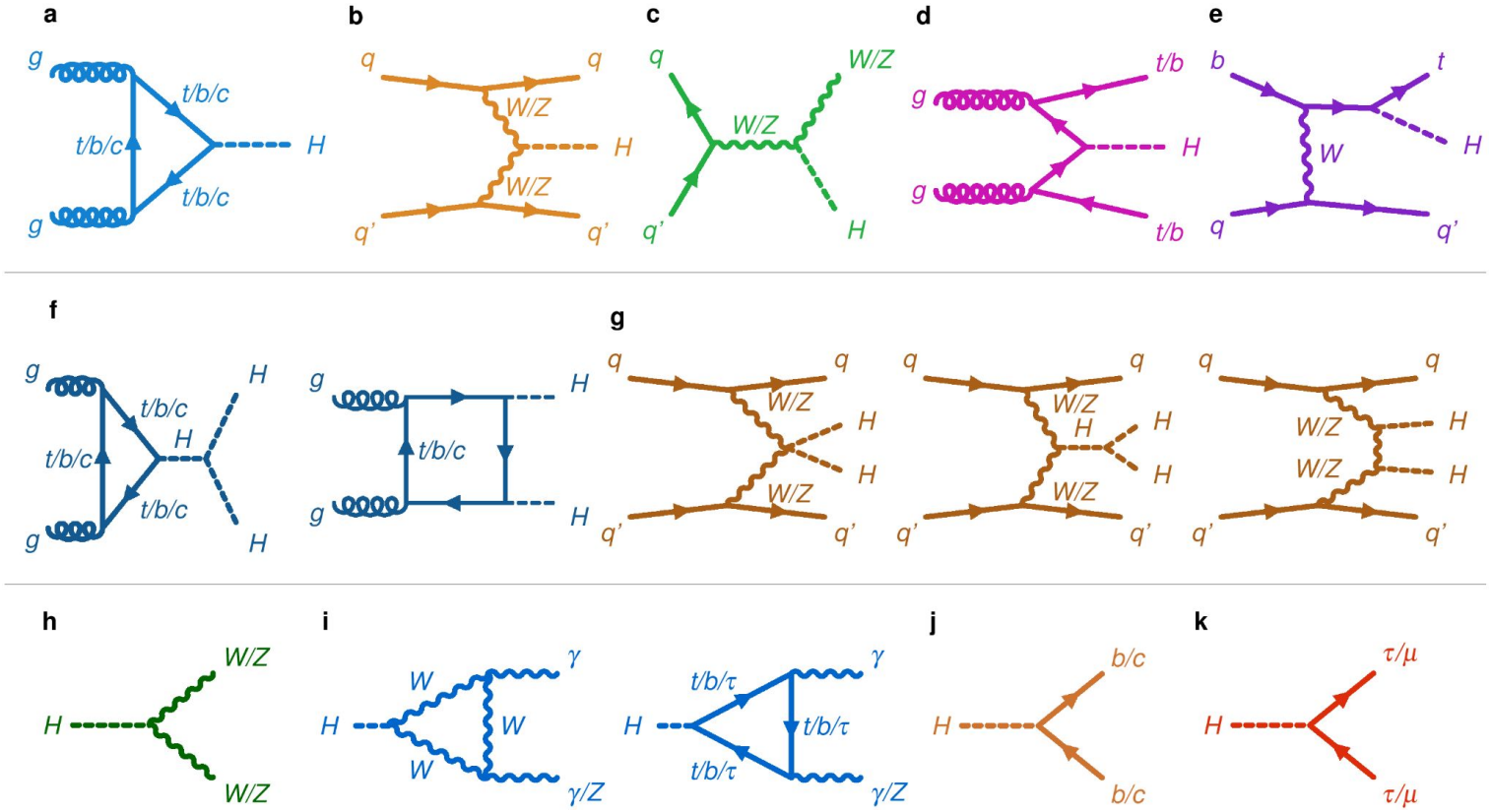
ATLAS HH→ 2b2τ, 196 fb-1



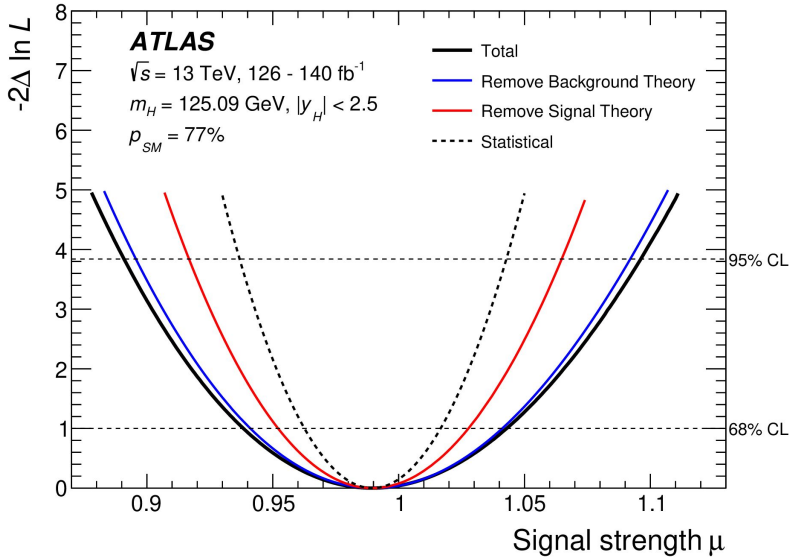
CMS HH→ 2b2τ, 310 fb-1



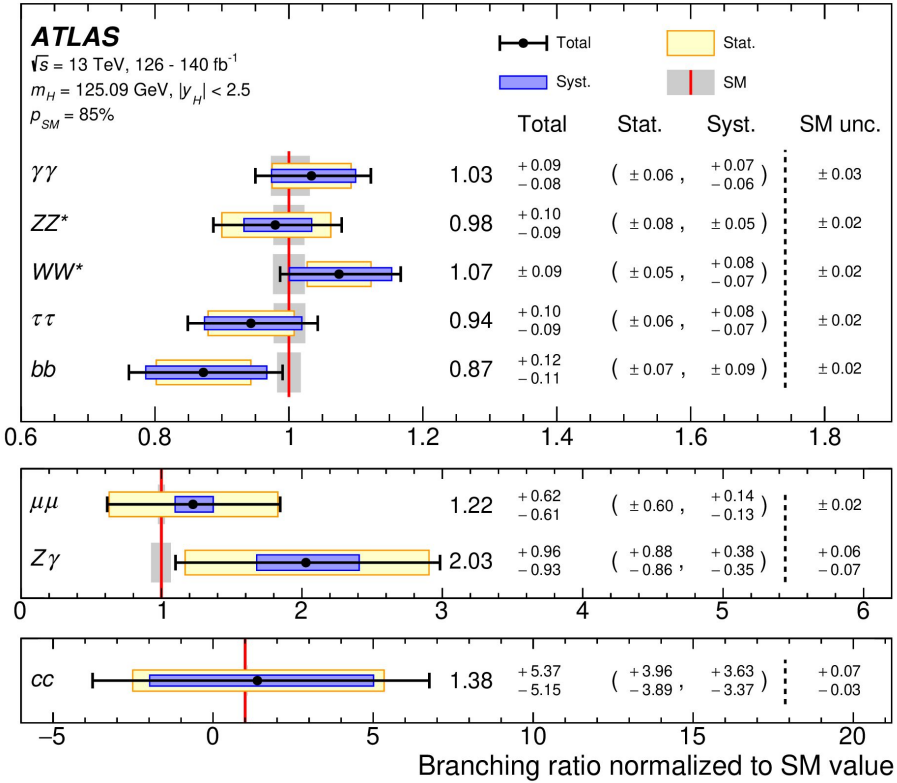
Main production modes and decay modes



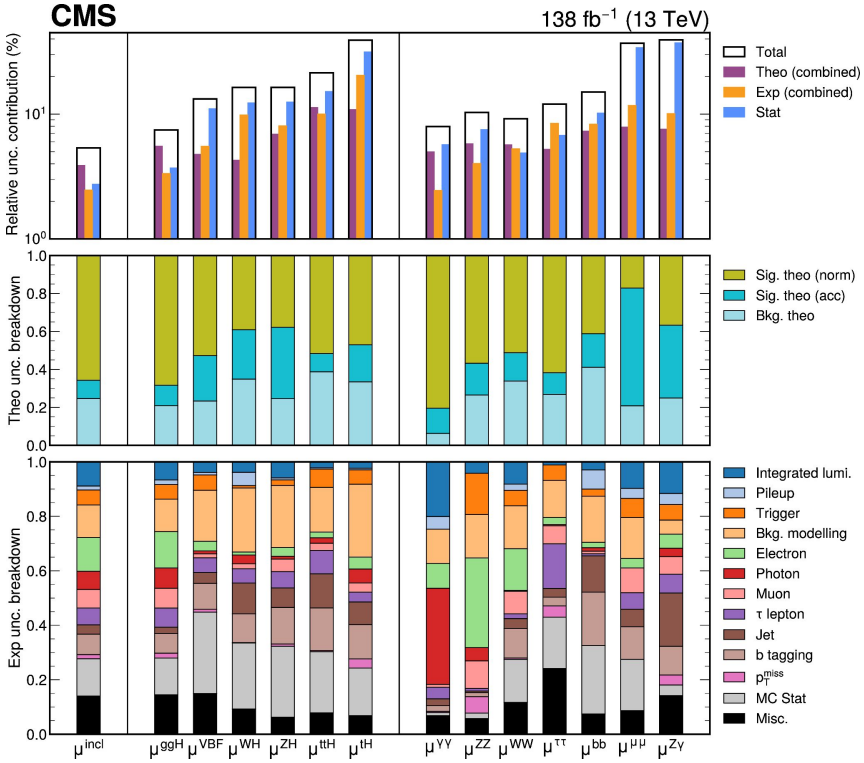
Higgs Signal Strength



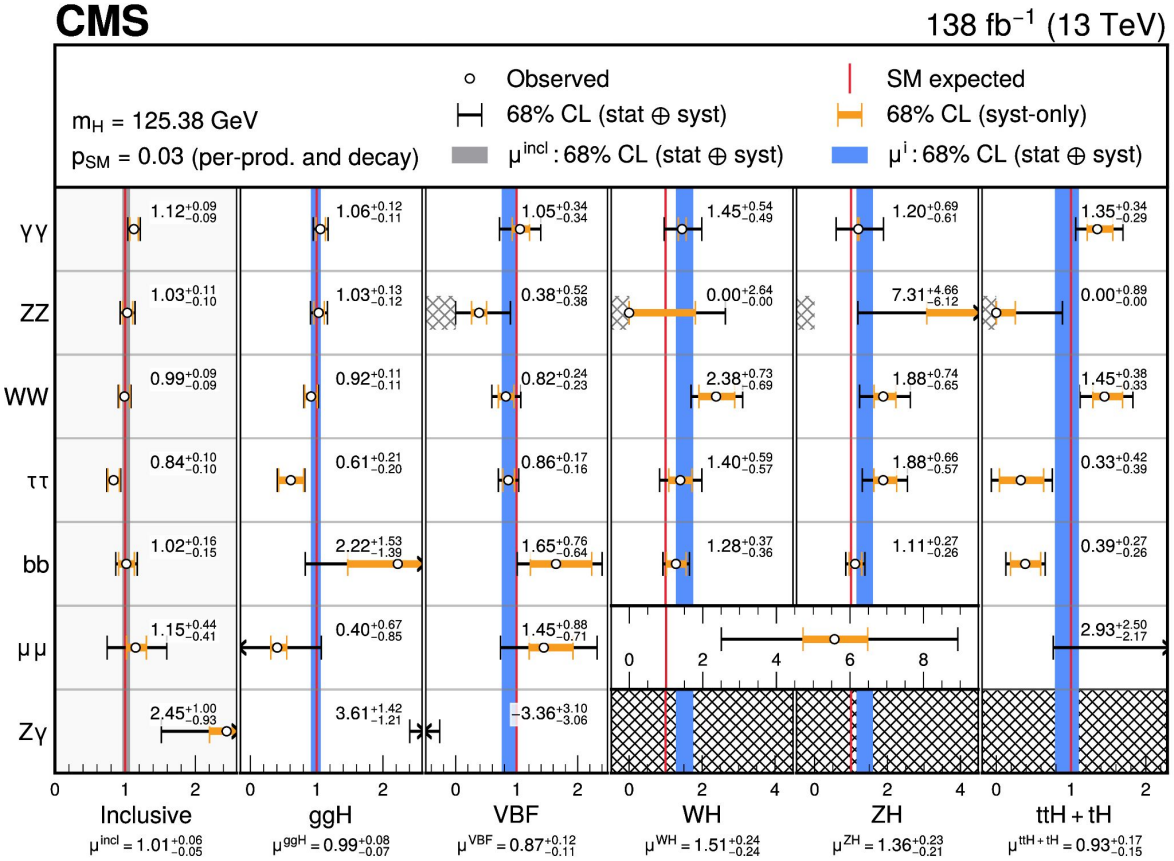
Decay modes


ATLAS
√s = 13 TeV, 126 - 140 fb-1
mH = 125.09 GeV, |yH| < 2.5
pSM = 85%
Total
Stat.
Syst.
SM
Total
Stat.
Syst.
SM unc.
γγ 1.03 +0.09 −0.08 (±0.06 , +0.07 −0.06) ±0.03
ZZ* 0.98 +0.10 −0.09 (±0.08 , ±0.05) ±0.02
WW* 1.07 ±0.09 (±0.05 , +0.08 −0.07) ±0.02
ττ 0.94 +0.10 −0.09 (±0.06 , +0.08 −0.07) ±0.02
bb 0.87 +0.12 −0.11 (±0.07 , ±0.09) ±0.02
0.6
0.8
1
1.2
1.4
1.6
1.8
μμ 1.22 +0.62 −0.61 (±0.60 , +0.14 −0.13) ±0.02
Zγ 2.03 +0.96 −0.93 (+0.88 −0.86 , +0.38 −0.35) +0.06 −0.07
0
1
2
3
4
5
6
cc 1.38 +5.37 −5.15 (+3.96 −3.89 , +3.63 −3.37) +0.07 −0.03
−5
0
5
10
15
20
Branching ratio normalized to SM value

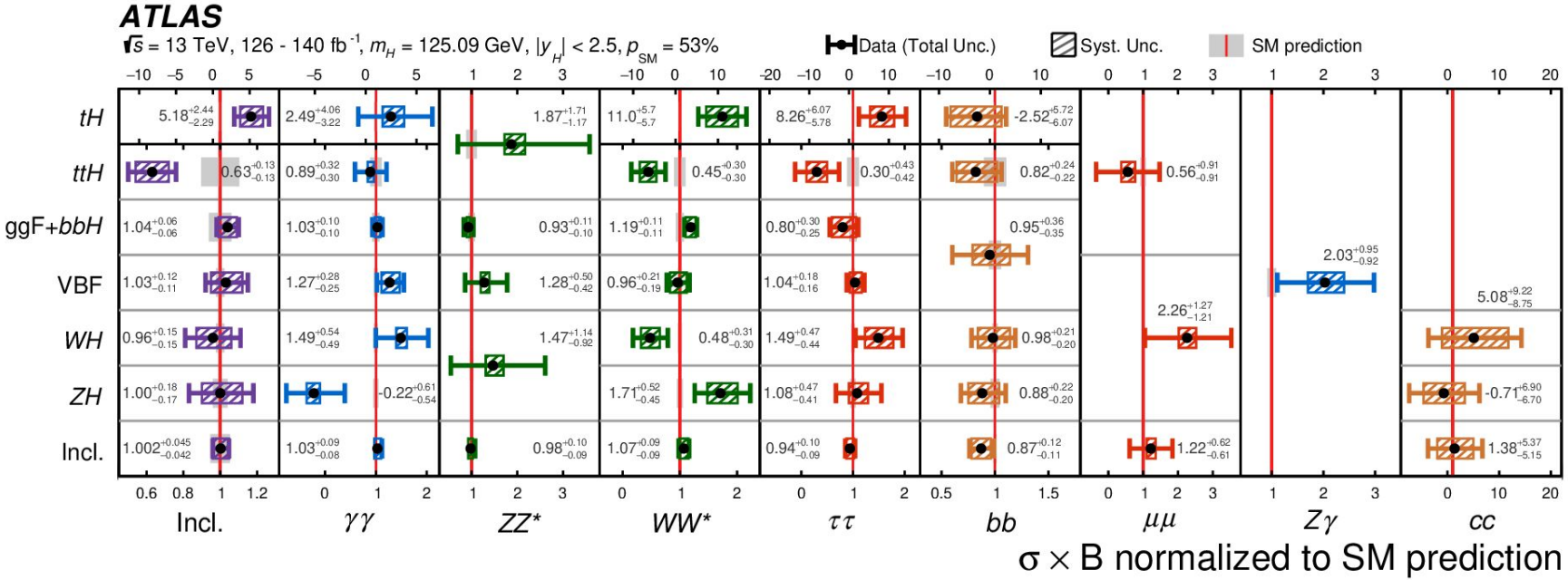
Errors in production and decay mode



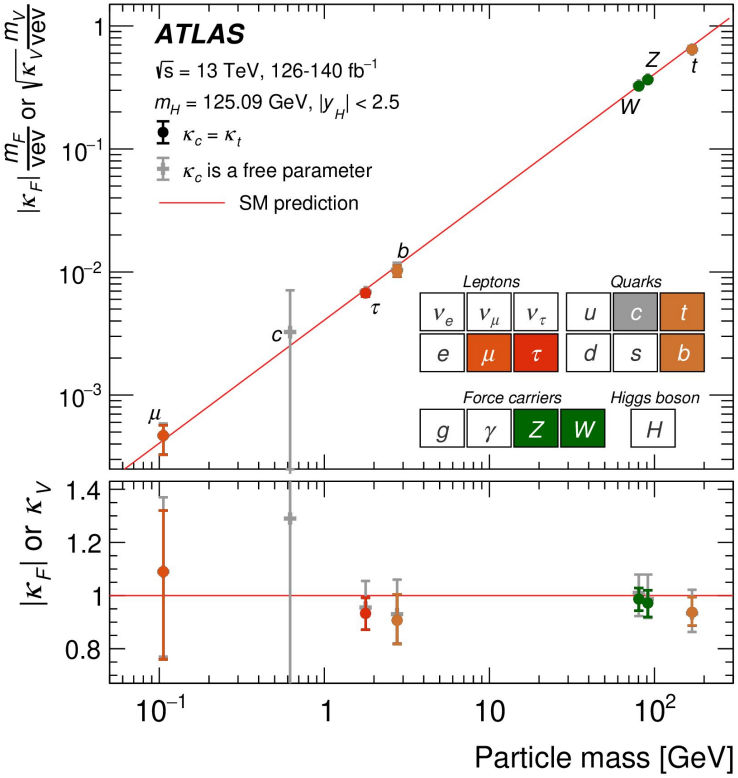
Production and decay modes

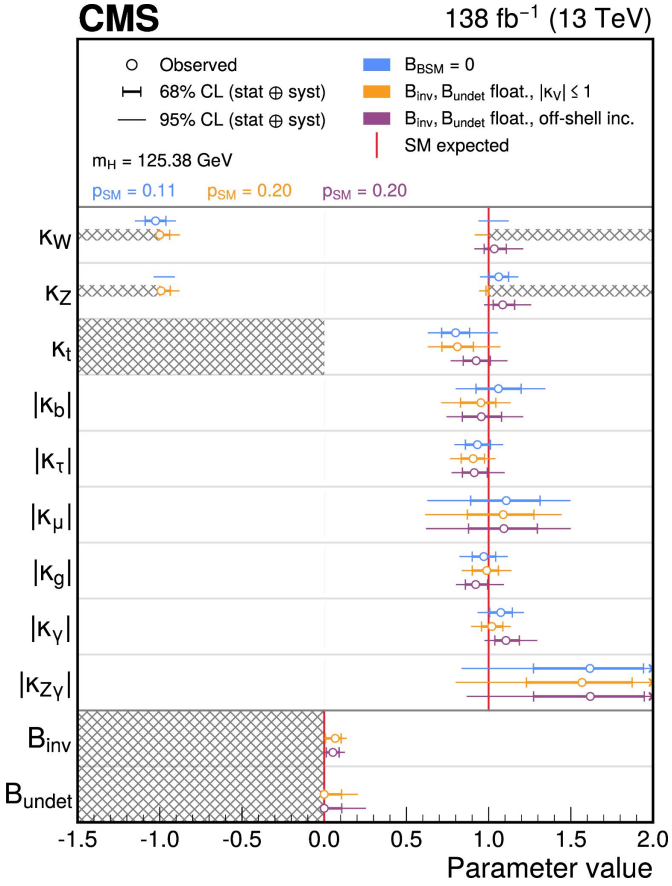


Production and decay modes

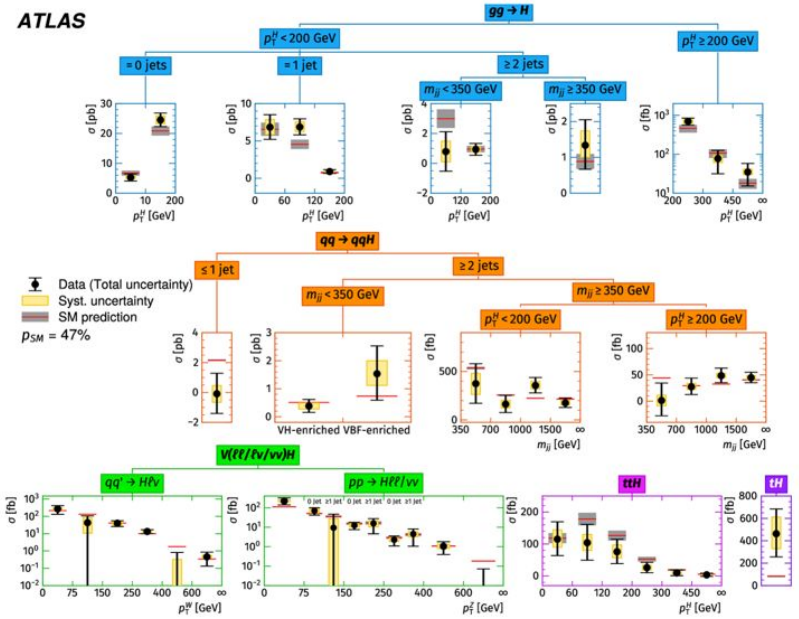


Couplings

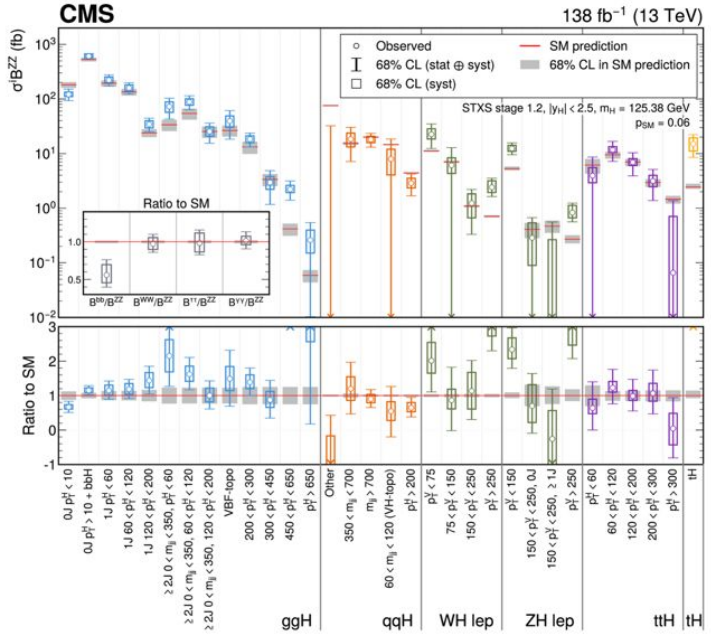

ATLAS
√s = 13 TeV, 126-140 fb⁻¹
m_H = 125.09 GeV, |y_H| < 2.5
κ_c = κ_t
κ_c is a free parameter
SM prediction
Leptons
Quarks
Force carriers
Higgs boson
Particle mass [GeV]


CMS
138 fb⁻¹ (13 TeV)
Observed
68% CL (stat ⊕ syst)
95% CL (stat ⊕ syst)
B_BSM = 0
B_inv, B_undet float., |κ_V| ≤ 1
B_inv, B_undet float., off-shell inc.
SM expected
m_H = 125.38 GeV
p_SM = 0.11
p_SM = 0.20
p_SM = 0.20
Parameter value

Beyond Inclusive Rates



ATLAS, arXiv:2608.07332



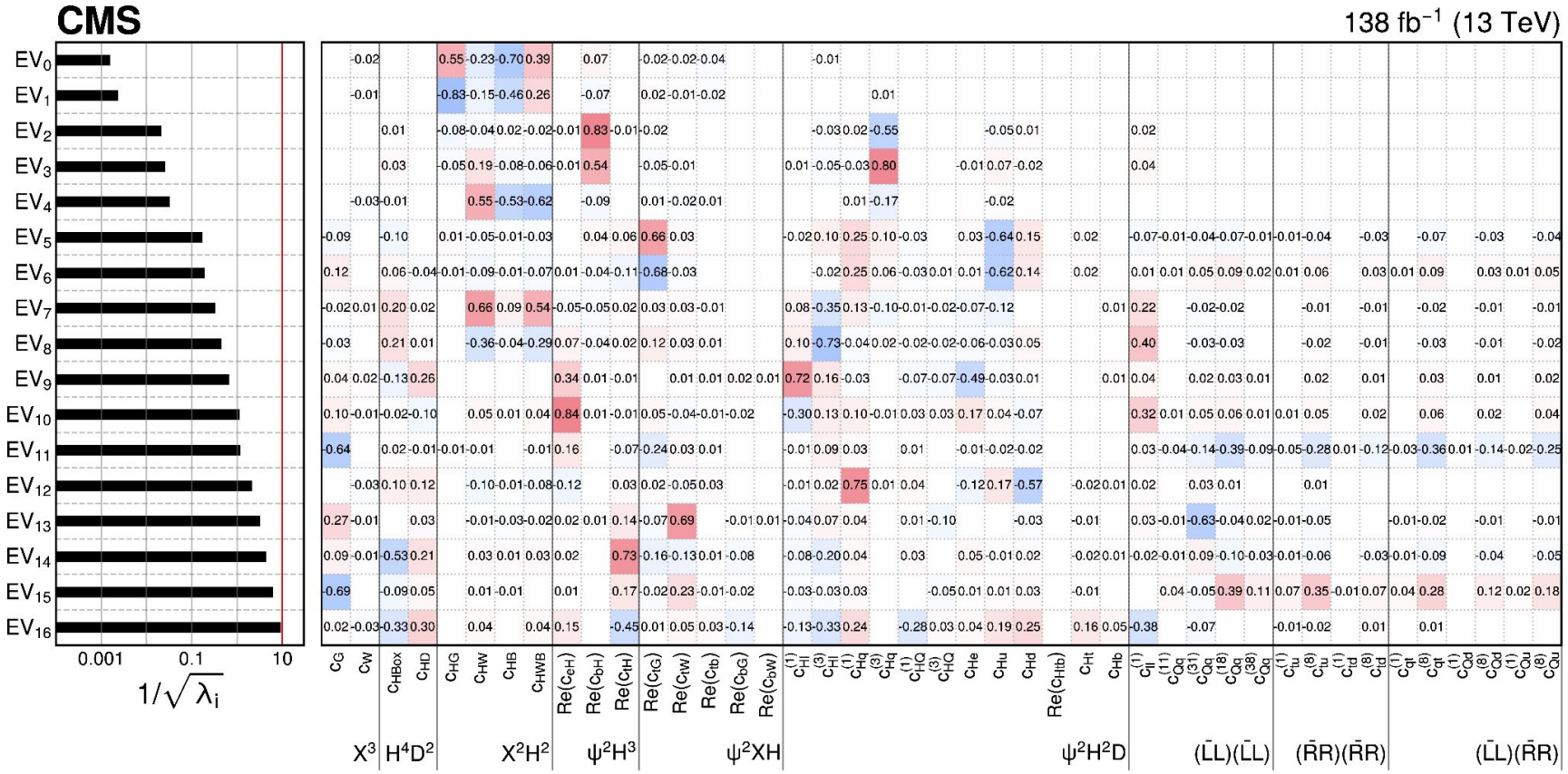
CMS, Rep. Prog. Phys. 89 (2026) 087801

Kinematic regions turn inclusive agreement into more detailed tests of Higgs interactions.
ATLAS measures 44 STXS regions and CMS 32, with different binning choices.

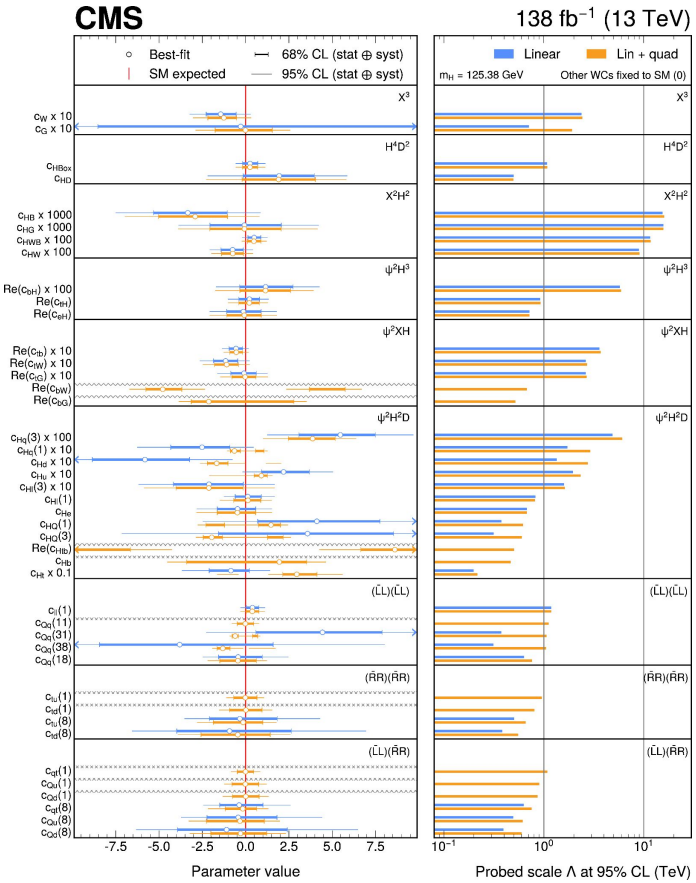
Light quarks couplings from Offshell

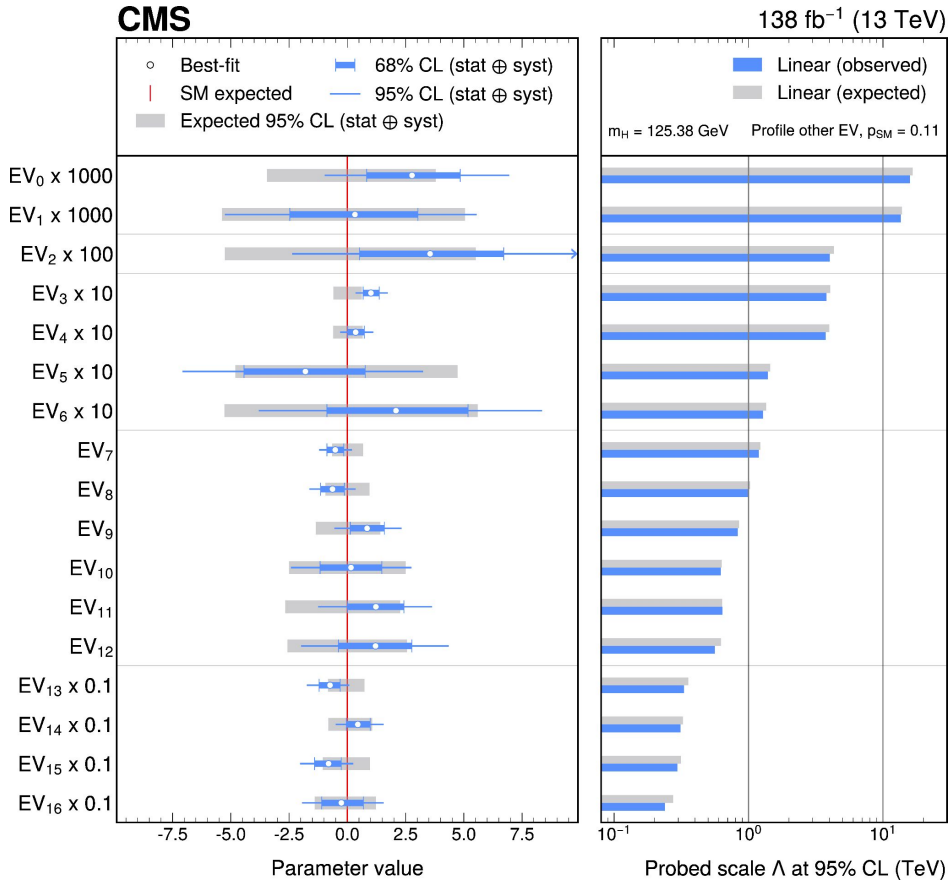
κ_q	Scenario	Observed		Expected	
		68% CL	95% CL	68% CL	95% CL
κ_u	All free	$(0.0 \pm 1.7) \times 10^3$	$[-3.0, 3.0] \times 10^3$	$(0.0^{+2.4}_{-2.6}) \times 10^3$	$[-4.3, 4.3] \times 10^3$
κ_u	$\lvert\kappa_V\rvert \leq 1$	$(0.0 \pm 1.4) \times 10^3$	$[-2.1, 2.1] \times 10^3$	$(0.0 \pm 1.7) \times 10^3$	$[-2.5, 2.5] \times 10^3$
κ_d	All free	$(0.00 \pm 0.90) \times 10^3$	$[-1.60, 1.60] \times 10^3$	$(0.0 \pm 1.3) \times 10^3$	$[-2.2, 2.2] \times 10^3$
κ_d	$\lvert\kappa_V\rvert \leq 1$	$(0.0 \pm 6.0) \times 10^2$	$[-8.6, 8.6] \times 10^2$	$(0.0 \pm 6.8) \times 10^2$	$[-9.6, 9.5] \times 10^2$
κ_s	All free	0^{+61}_{-64}	$[-98, 94]$	1^{+76}_{-81}	$[-116, 112]$
κ_s	$\lvert\kappa_V\rvert \leq 1$	0^{+26}_{-28}	$[-38, 36]$	1^{+27}_{-30}	$[-40, 39]$
κ_c	All free	-0.4 ± 5.7	$[-8.6, 7.5]$	$1.0^{+5.1}_{-7.9}$	$[-9.6, 8.3]$
κ_c	$\lvert\kappa_V\rvert \leq 1$	$-0.3^{+2.3}_{-2.2}$	$[-3.3, 2.8]$	$1.0^{+1.2}_{-3.5}$	$[-3.5, 2.9]$

EFT

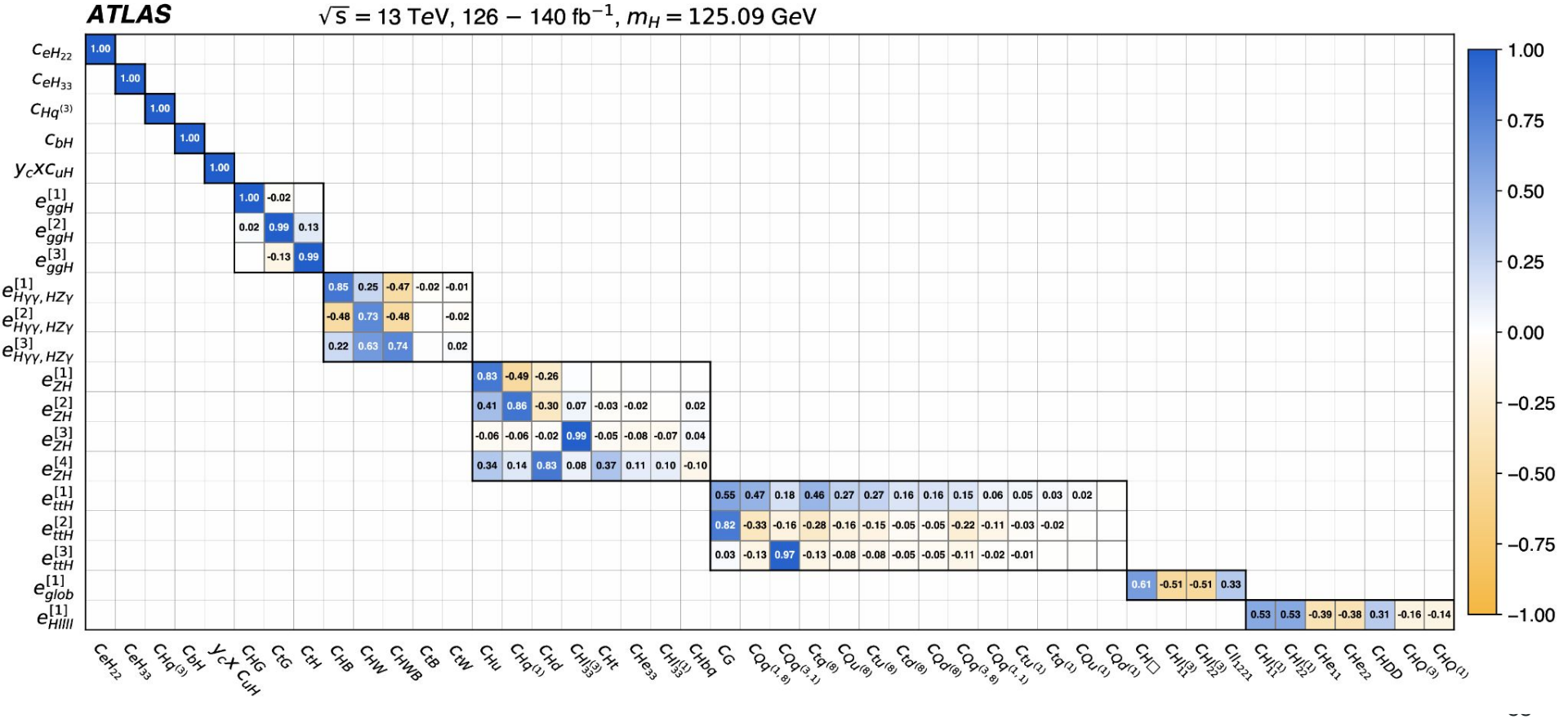

CMS
138 fb^{-1} (13 TeV)
EV$_0$
EV$_1$
EV$_2$
EV$_3$
EV$_4$
EV$_5$
EV$_6$
EV$_7$
EV$_8$
EV$_9$
EV$_{10}$
EV$_{11}$
EV$_{12}$
EV$_{13}$
EV$_{14}$
EV$_{15}$
EV$_{16}$
0.001
0.1
10
$1/\sqrt{\lambda_i}$
c_G c_W c_{HBox} c_{HD} c_{HG} c_{HW} c_{HB} c_{HWB} Re(c_{eH}) Re(c_{bH}) Re(c_{tH}) Re(c_{tG}) Re(c_{tW}) Re(c_{tb}) Re(c_{bG}) Re(c_{bW}) $c_{Hl}^{(1)}$ $c_{Hl}^{(3)}$ $c_{Hq}^{(1)}$ $c_{Hq}^{(3)}$ $c_{HQ}^{(1)}$ $c_{HQ}^{(3)}$ c_{He} c_{Hu} c_{Hd} Re(c_{tHb}) c_{Ht} c_{Hb} $c_{ll}^{(1)}$ $c_{ll}^{(11)}$ $c_{Qq}^{(31)}$ $c_{Qq}^{(18)}$ $c_{Qq}^{(38)}$ $c_{lu}^{(1)}$ $c_{lu}^{(8)}$ $c_{ld}^{(1)}$ $c_{ld}^{(8)}$ $c_{qe}^{(1)}$ $c_{qe}^{(8)}$ $c_{Qd}^{(1)}$ $c_{Qd}^{(8)}$ $c_{Qu}^{(1)}$ $c_{Qu}^{(8)}$
X^3 H^{4}D^2 X^{2}H^2 ψ^2H^3 ψ^2XH ψ^2H^{2}D (LL)(LL) (RR)(RR) (LL)(RR)

EFT

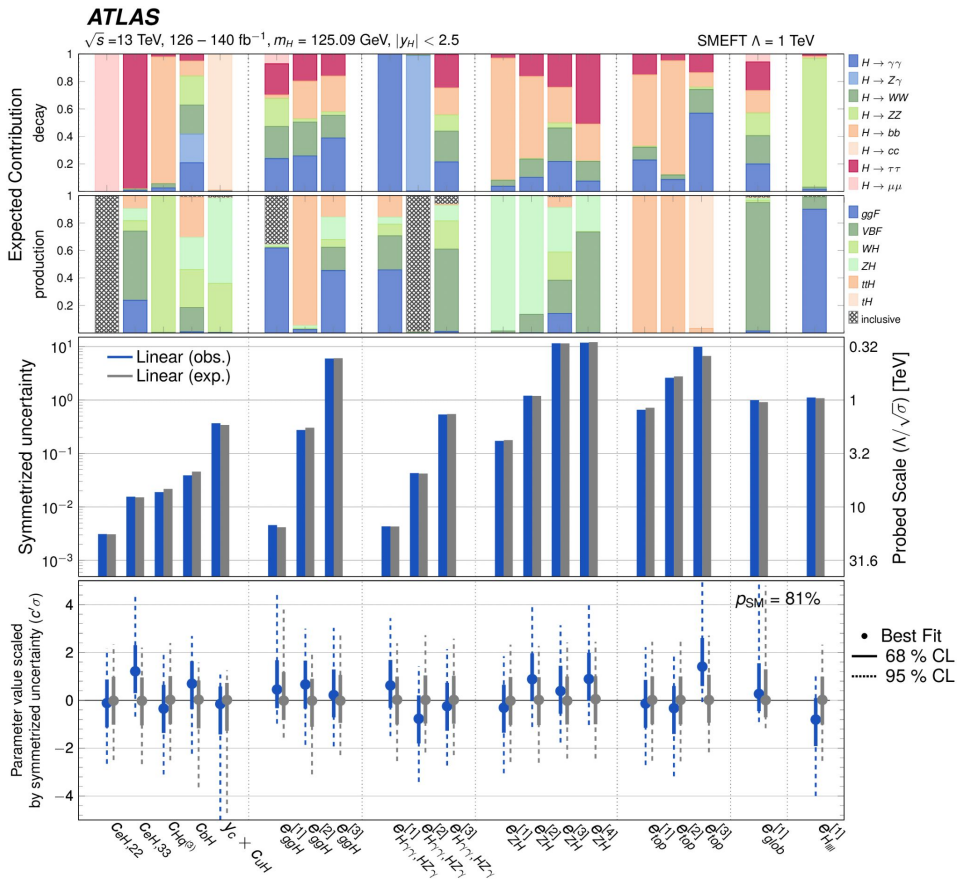

CMS
138 fb^{-1} (13 TeV)
Best-fit
SM expected
68% CL (stat ⊕ syst)
95% CL (stat ⊕ syst)
Linear
Lin + quad
m_H = 125.38 GeV
Other WCs fixed to SM (0)
X^3
H^4D^2
X^2H^2
ψ^2H^3
ψ^2XH
ψ^2H^2D
$(\bar{L}L)(\bar{L}L)$
$(\bar{R}R)(\bar{R}R)$
$(\bar{L}L)(\bar{R}R)$
c_W x 10
c_G x 10
c_{HBox}
c_{HD}
c_{HB} x 1000
c_{HG} x 1000
c_{HWB} x 100
c_{HW} x 100
$Re(c_{eH})$ x 100
$Re(c_{eH})$
$Re(c_{eH})$
$Re(c_{tb})$ x 10
$Re(c_{tW})$ x 10
$Re(c_{tG})$ x 10
$Re(c_{bW})$
$Re(c_{bG})$
$c_{Hq}(3)$ x 100
$c_{Hq}(1)$ x 10
c_{Hd} x 10
c_{Hu} x 10
$c_{Hd}(3)$ x 10
$c_{Hl}(1)$
c_{He}
$c_{HQ}(1)$
$c_{HQ}(3)$
$Re(c_{Hb})$
c_{Hb}
c_H x 0.1
$c_{ll}(1)$
$c_{Qq}(11)$
$c_{Qq}(31)$
$c_{Qq}(38)$
$c_{Qq}(18)$
$c_{lu}(1)$
$c_{ld}(1)$
$c_{lu}(8)$
$c_{ld}(8)$
$c_{qe}(1)$
$c_{Qu}(1)$
$c_{Qd}(1)$
$c_{qe}(8)$
$c_{Qu}(8)$
$c_{Qd}(8)$
-7.5 -5.0 -2.5 0.0 2.5 5.0 7.5
Parameter value
10^{-1} 10^0 10^1
Probed scale Λ at 95% CL (TeV)

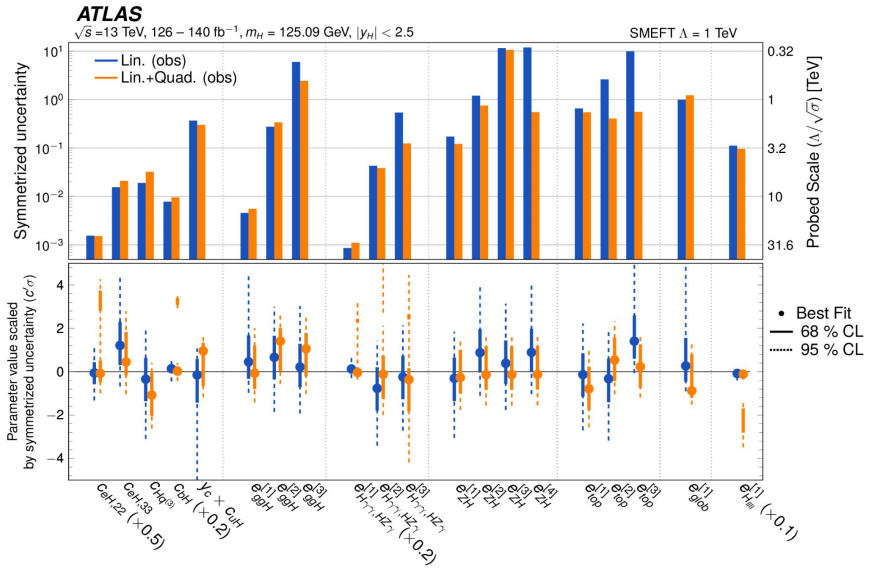

CMS
138 fb^{-1} (13 TeV)
Best-fit
SM expected
Expected 95% CL (stat ⊕ syst)
68% CL (stat ⊕ syst)
95% CL (stat ⊕ syst)
Linear (observed)
Linear (expected)
m_H = 125.38 GeV
Profile other EV, p_{SM} = 0.11
EV_0 x 1000
EV_1 x 1000
EV_2 x 100
EV_3 x 10
EV_4 x 10
EV_5 x 10
EV_6 x 10
EV_7
EV_8
EV_9
EV_{10}
EV_{11}
EV_{12}
EV_{13} x 0.1
EV_{14} x 0.1
EV_{15} x 0.1
EV_{16} x 0.1
-7.5 -5.0 -2.5 0.0 2.5 5.0 7.5
Parameter value
10^{-1} 10^0 10^1
Probed scale Λ at 95% CL (TeV)

EFT

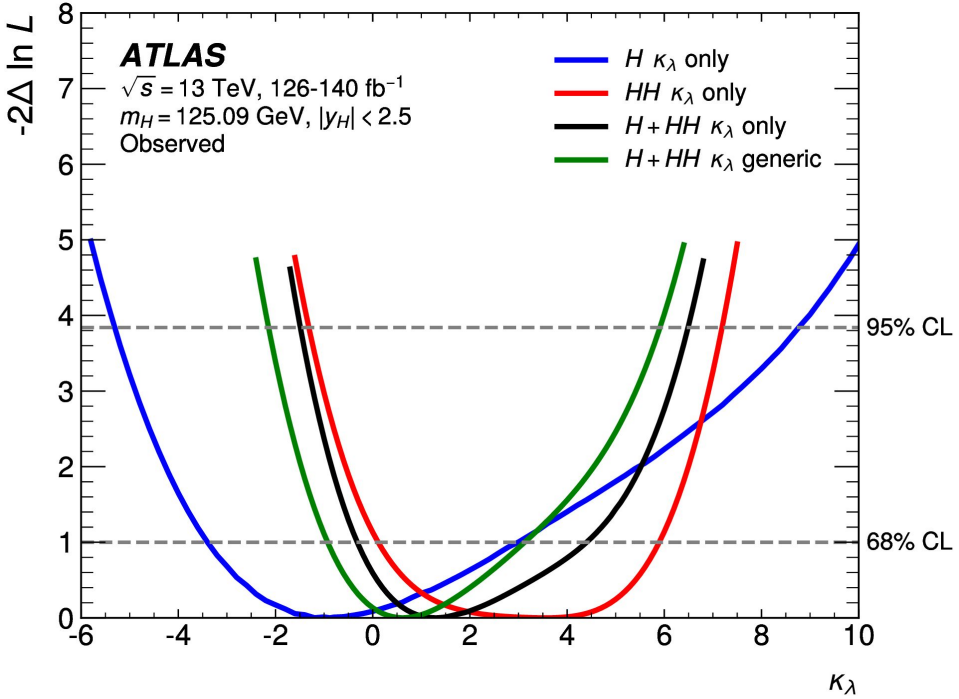

ATLAS
$\sqrt{s} = 13$ TeV, 126 − 140 fb^{-1}, $m_H = 125.09$ GeV
$c_{eH_{22}}$
$c_{eH_{33}}$
$c_{Hq^{(3)}}$
c_{bH}
$y_c x c_{uH}$
$e^{[1]}_{ggH}$
$e^{[2]}_{ggH}$
$e^{[3]}_{ggH}$
$e^{[1]}_{H\gamma\gamma, HZ\gamma}$
$e^{[2]}_{H\gamma\gamma, HZ\gamma}$
$e^{[3]}_{H\gamma\gamma, HZ\gamma}$
$e^{[1]}_{ZH}$
$e^{[2]}_{ZH}$
$e^{[3]}_{ZH}$
$e^{[4]}_{ZH}$
$e^{[1]}_{ttH}$
$e^{[2]}_{ttH}$
$e^{[3]}_{ttH}$
$e^{[1]}_{glob}$
$e^{[1]}_{HIIII}$
1.00
0.75
0.50
0.25
0.00
−0.25
−0.50
−0.75
−1.00

EFT


ATLAS
√s =13 TeV, 126 – 140 fb⁻¹, m_H = 125.09 GeV, |y_H| < 2.5
SMEFT Λ = 1 TeV
Expected Contribution
decay
production
H → γγ
H → Zγ
H → WW
H → ZZ
H → bb
H → cc
H → ττ
H → μμ
ggF
VBF
WH
ZH
ttH
tH
inclusive
Symmetrized uncertainty
Linear (obs.)
Linear (exp.)
Probed Scale (Λ/√σ) [TeV]
0.32
1
3.2
10
31.6
Parameter value scaled
by symmetrized uncertainty (σ'/σ)
p_SM = 81%
Best Fit
68 % CL
95 % CL
c_eH,22
c_eH,33
c_Hq(3)
c_bH
y_c × c_uH
e[1]_ggH
e[2]_ggH
e[3]_ggH
e[1]_H→γγ,HZγ
e[2]_H→γγ,HZγ
e[3]_H→γγ,HZγ
e[1]_ZH
e[2]_ZH
e[3]_ZH
e[4]_ZH
e[1]_top
e[2]_top
e[3]_top
e[1]_glob
e[1]_Hμμ


ATLAS
√s =13 TeV, 126 – 140 fb⁻¹, m_H = 125.09 GeV, |y_H| < 2.5
SMEFT Λ = 1 TeV
Lin. (obs)
Lin.+Quad. (obs)
Symmetrized uncertainty
Probed Scale (Λ/√σ) [TeV]
0.32
1
3.2
10
31.6
Parameter value scaled
by symmetrized uncertainty (σ'/σ)
Best Fit
68 % CL
95 % CL
c_eH,22 (×0.5)
c_eH,33
c_Hq(3)
c_bH (×0.2)
y_c × c_uH
e[1]_ggH
e[2]_ggH
e[3]_ggH
e[1]_H→γγ,HZγ (×0.2)
e[2]_H→γγ,HZγ
e[3]_H→γγ,HZγ
e[1]_ZH
e[2]_ZH
e[3]_ZH
e[4]_ZH
e[1]_top
e[2]_top
e[3]_top
e[1]_glob
e[1]_Hμμ (×0.1)

Run2 H+HH κ_λ



HL-LHC and FCC

Coupling	HL-LHC	FCC-ee	FCC-ee + FCC-hh
κ_Z (%)	1.3*	0.10	0.10
κ_W (%)	1.5*	0.29	0.25
κ_b (%)	2.5*	0.38 / 0.49	0.33 / 0.45
κ_g (%)	2*	0.49 / 0.54	0.41 / 0.44
κ_τ (%)	1.6*	0.46	0.40
κ_c (%)	–	0.70 / 0.87	0.68 / 0.85
κ_γ (%)	1.6*	1.1	0.30
$\kappa_{Z\gamma}$ (%)	10*	4.3	0.67
κ_t (%)	3.2*	3.1	0.75
κ_μ (%)	4.4*	3.3	0.42
$\lvert\kappa_s\rvert$ (%)	–	$^{+29}_{-67}$	$^{+29}_{-67}$
Γ_H (%)	–	0.78	0.69
$\mathcal{B}_{inv}$ (<, 95% CL)	1.9×10^{-2} *	5×10^{-4}	2.3×10^{-4}
$\mathcal{B}_{unt}$ (<, 95% CL)	4×10^{-2} *	6.8×10^{-3}	6.7×10^{-3}

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