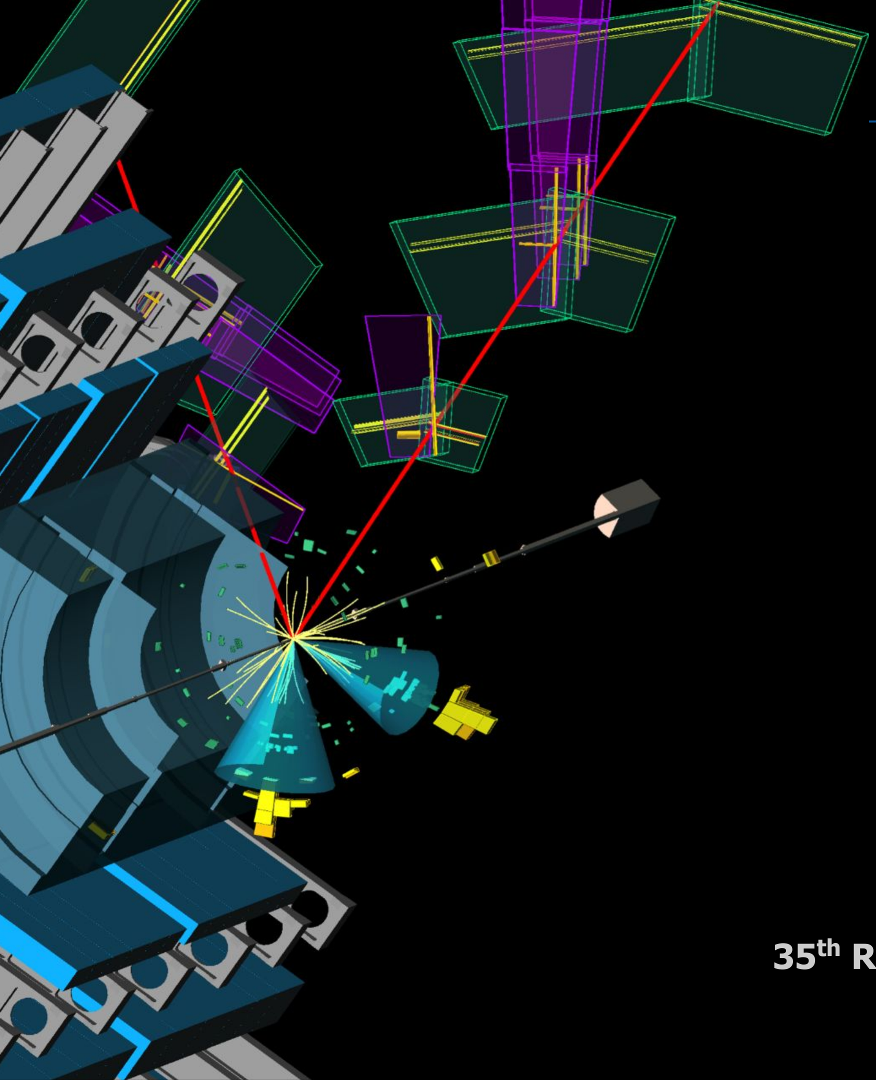


The Higgs boson

Couplings and properties measurements

Hannah Arnold (Stony Brook University)

On behalf of the ATLAS and CMS collaborations

35th Recontres des Blois on "Particle Physics and Cosmology"

October 21, 2024

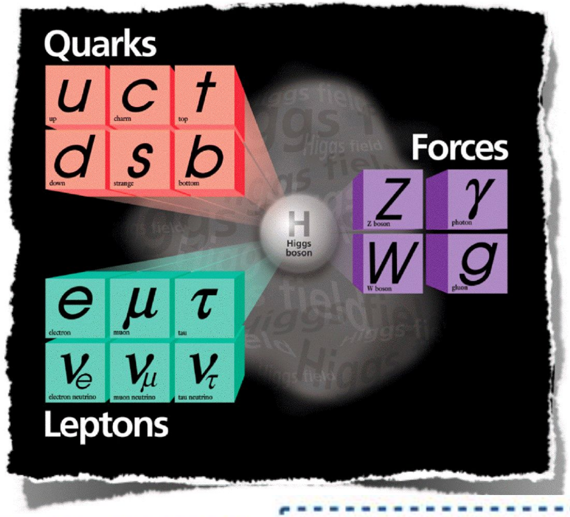
At the heart of the Standard Model (SM)

$$\mathcal{L} = -\frac{1}{4} F_{\mu\nu} F^{\mu\nu}$$

$$+ i \bar{\psi} \not{D} \psi + h.c.$$

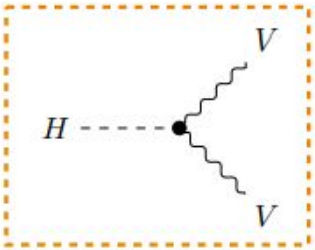
$$+ \bar{\psi}_i y_{ij} \psi_j \phi + h.c.$$ Yukawa terms

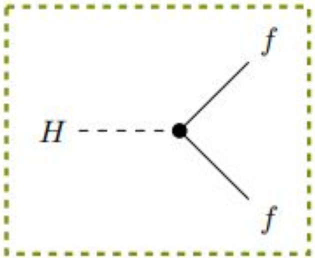
$$+ |D_\mu \phi|^2 - V(\phi)$$ Brout-Englert-Higgs mechanism

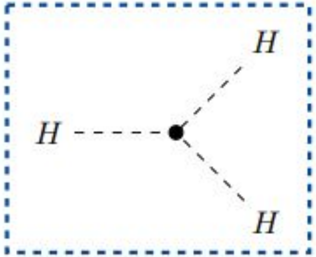


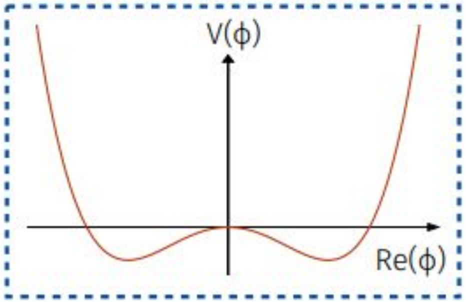
Higgs boson
CP-even scalar

W and Z bosons and charged fermions acquire mass through interaction with the Higgs field Φ









⇒ 15 out of the 19 free parameters of the SM are connected to the Higgs boson

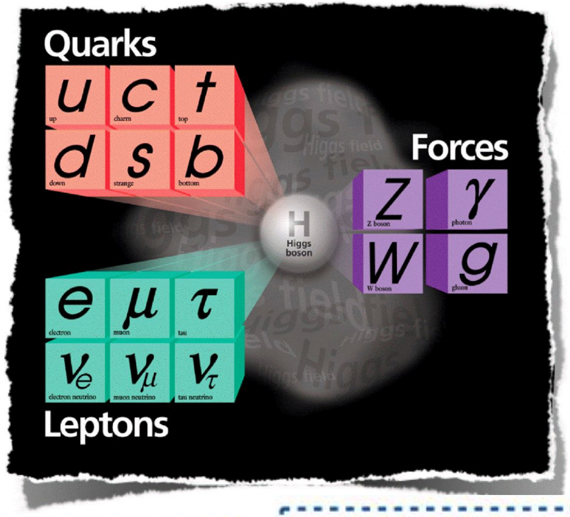
Predicted properties of the Higgs boson

Stony Brook University

…that can be (more or less well) tested

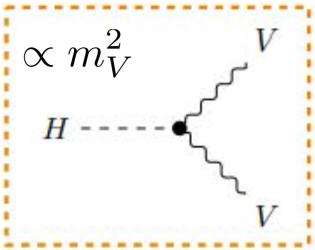
Couples to all massive bosons and fermions
with a strength related to the particles' mass
⇒ production cross-section
branching ratios
total decay width
…

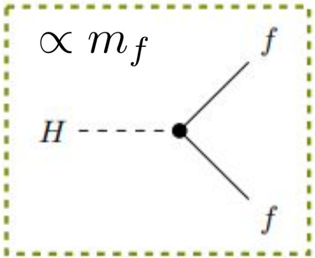
…once m_H is known

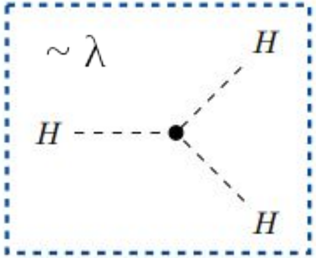


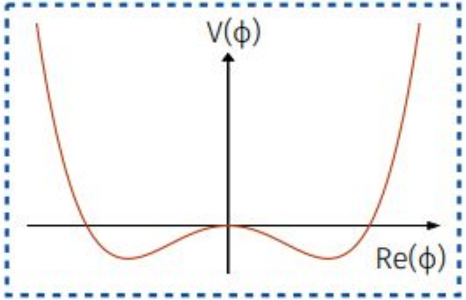
Higgs boson
CP-even scalar
⇒ elementary
electrically neutral
spin 0
parity even

self-coupling λ
HH production









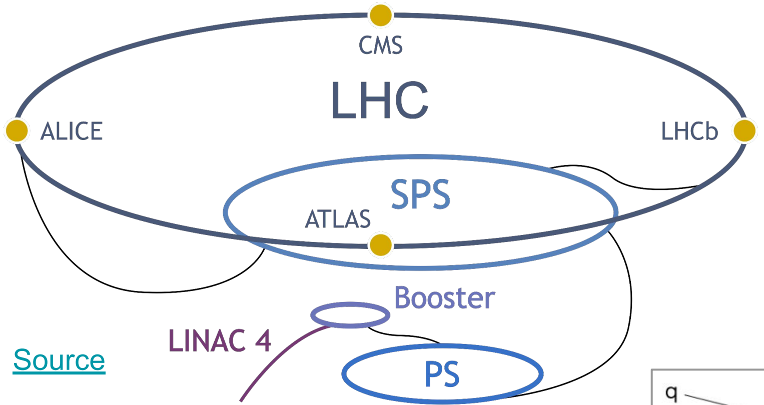
⇒ 15 out of the 19 free parameters of the SM are connected to the Higgs boson

Rich phenomenology at the LHC

Stony Brook University

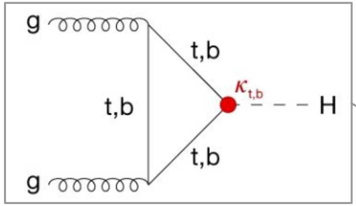
Run 2: 2015-2018
⇒ ~8 million Higgs bosons

Run 3: 2022-2026 (?)
⇒ ~10 million Higgs bosons and counting…

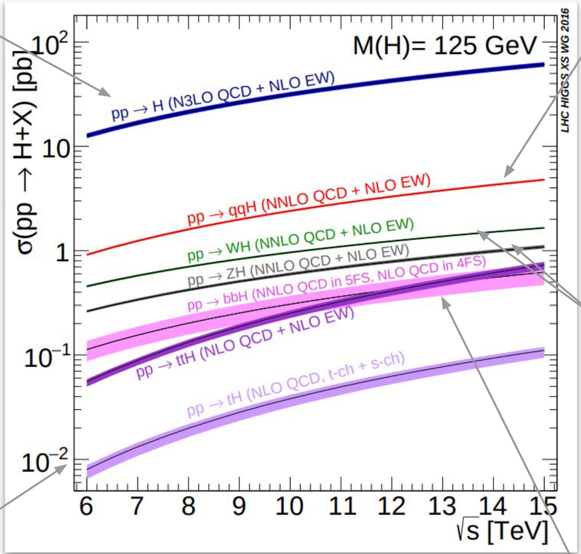


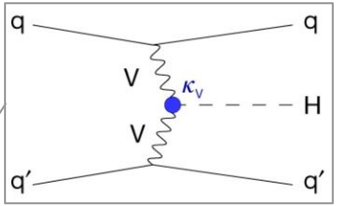
Source

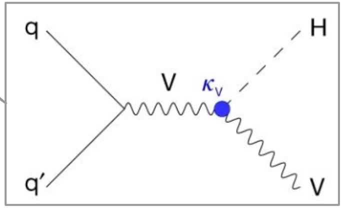
Large Hadron Collider (LHC)
Colliding proton bunches (p-p)

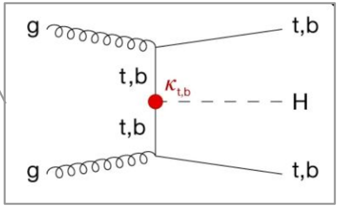


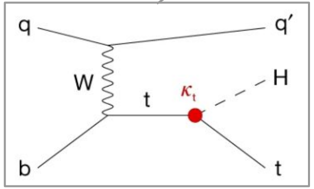
A variety of production modes



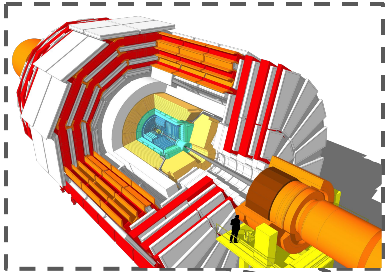


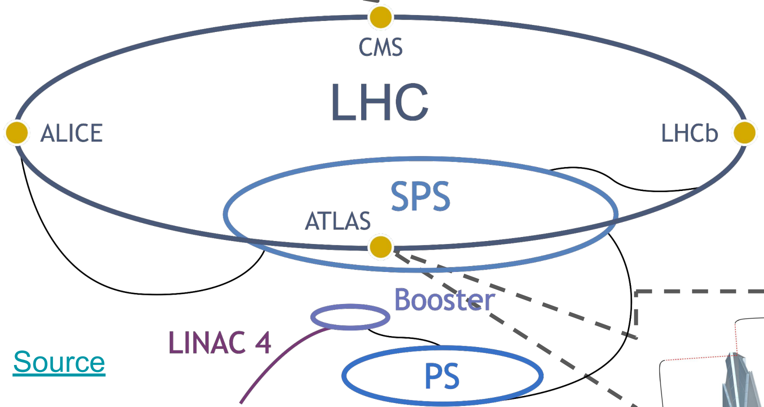






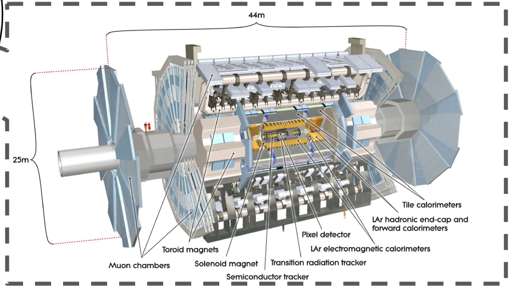
Rich phenomenology at the LHC



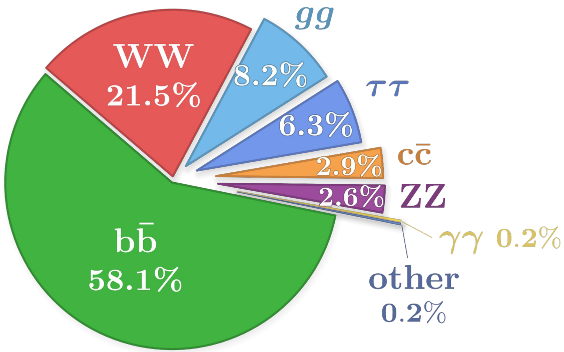


Source

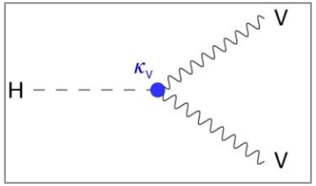
Large Hadron Collider (LHC)
Colliding proton bunches (p-p)

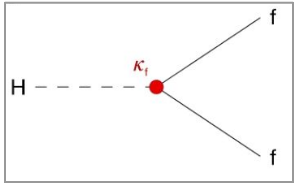


A variety of decay modes

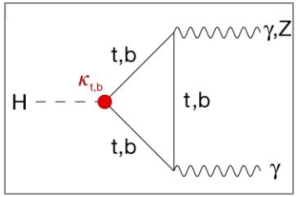


Branching fractions at m_H = 125 GeV;
total width ~4 MeV





Or, indirectly, e.g.



⇒ General purpose experiments sensitive to many experimental signatures

Higgs-boson mass [state-of-the art, 2023]

Measured in clean final states where the Higgs boson can be fully reconstructed with excellent precision.
Full Run-2 dataset using most refined techniques + combination with Run 1.

CMS - H→ZZ*→ 4 leptons (e/**μ**) [HIG-21-019]

m_H = 125.08 ± 0.10 (stat.) ± 0.05 (syst.) GeV

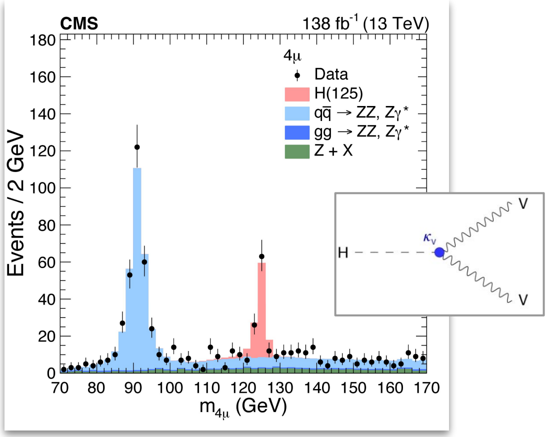
ATLAS - combination [Phys. Rev. Lett. 131 (2023) 251802]

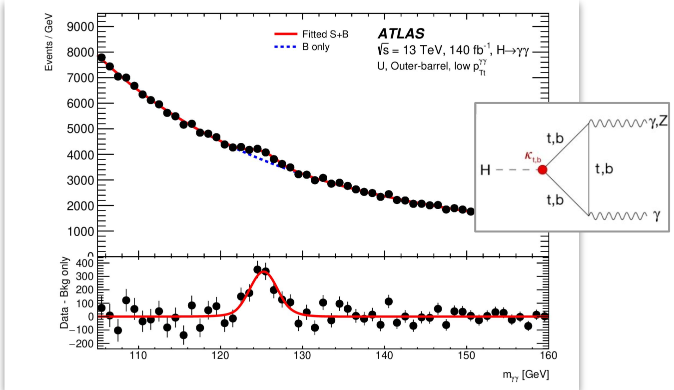
- **H→γγ**
- H→ZZ*→ 4 leptons (e/μ)

m_H = 125.11 ± 0.09 (stat.) ± 0.06 (syst.) GeV

⇒ **Most precise (*single*) measurements to date**; in very good agreement with each other

⇒ **Mass resolution: < 1‰**





Categories with the best mass resolution

Main production and decay modes [Status 2022]

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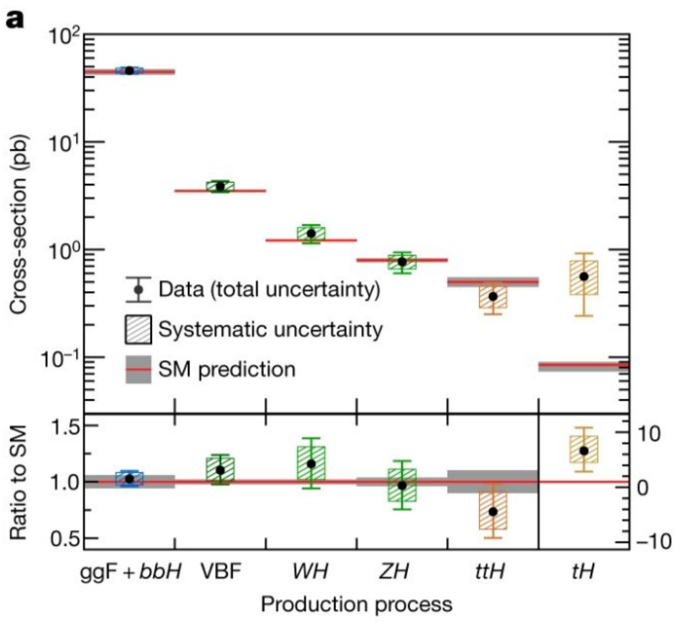
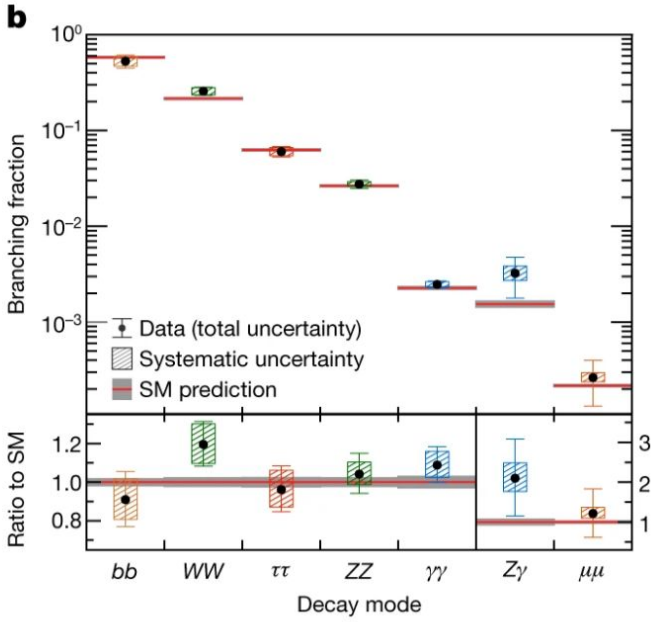
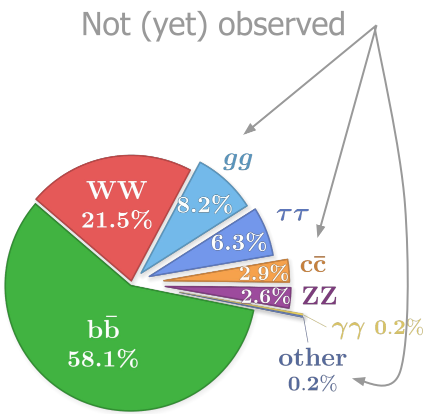






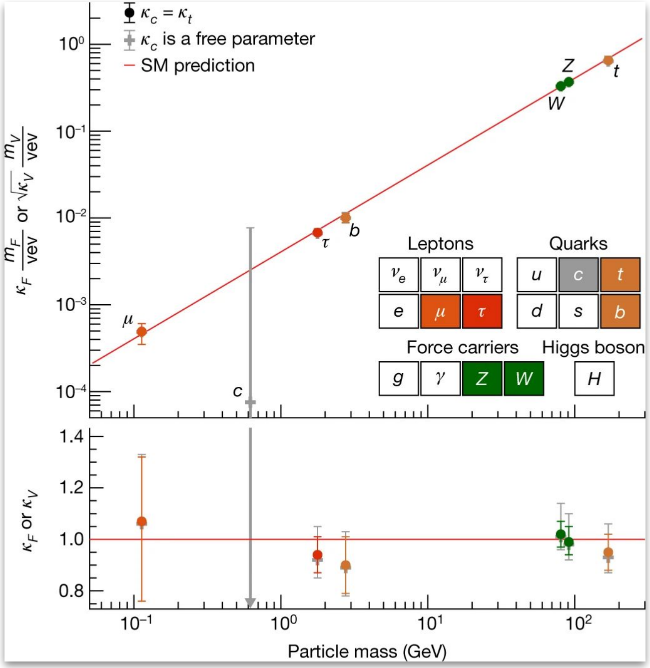
[ATLAS: Nature 607 52 (2022), CMS: Nature 607 60 (2022)]

Dominant production modes and > 88% of potential SM decays **observed and measured with < 10-20% precision.**

No bbH, upper per limit on tH production, observation of H→μμ,...

Couplings [Status 2022]

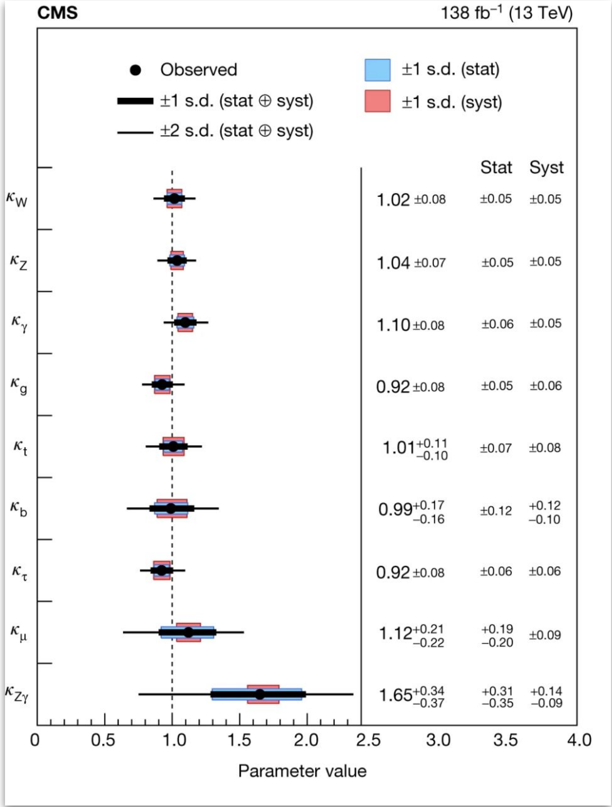
[Nature 607 52 (2022)]



(Reduced) κ

Particle mass

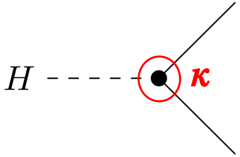
[Nature 607 60 (2022)]



Coupling

κ

Coupling-strength modifier κ



decay

production

$$\kappa_j^2 = \frac{\sigma_j}{\sigma_j^{SM}} \qquad \kappa_j^2 = \frac{\Gamma_j}{\Gamma_j^{SM}}$$

SM: $\kappa = 1$

Good agreement with the SM prediction within up to < 10% uncertainty; but still many missing pieces…

Are we done yet?

Stony Brook University

We've come a long way since the Higgs boson discovery in 2012. It looks like the SM Higgs boson, it couples like the SM Higgs boson,…?

The Higgs boson might be key to answering **many open questions**

Higgs boson

Why is the electroweak interaction so much stronger than gravity?

- Are there new particles close to the mass of the Higgs boson?
- Is the Higgs boson elementary or made of other particles?
- Are there anomalies in the interactions of the Higgs boson with the *W* and *Z* bosons?

Couplings to known particles

What is dark matter?

- Can the Higgs boson provide a portal to dark matter or a dark sector?
- Is the Higgs lifetime consistent with the Standard Model?
- Are there new decay modes of the Higgs boson?

Total decay width, lifetime

Why is there more matter than antimatter in the Universe?

- Are there charge-parity violating Higgs decays?
- Are there anomalies in the Higgs self-coupling that would imply a strong first-order early-Universe electroweak phase transition?
- Are there multiple Higgs sectors?

CP violation?

Self-coupling

What is the origin of the vast range of quark and lepton masses in the Standard Model?

- Are there modified interactions to the Higgs boson and known particles?
- Does the Higgs boson decay into pairs of quarks or leptons with distinct flavours (for example, $H \to \mu^+ \tau^-$)?

What is the origin of the early Universe inflation?

- Any imprint in cosmological observations?

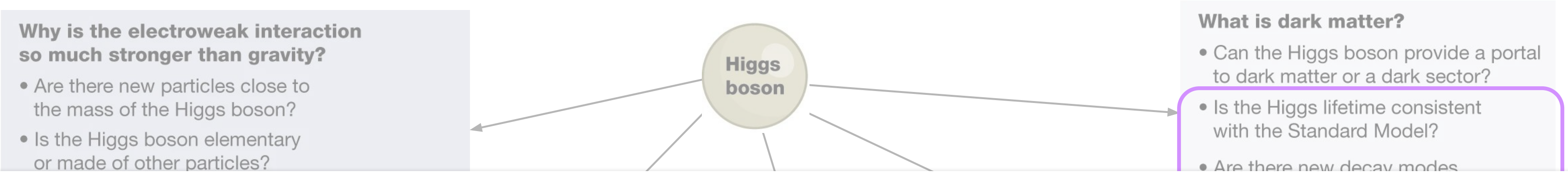
+much more
+ direct searches for new physics

Adapted from G. Salam et. al, Nature 607, 41 (2022)

Are we done yet?

We've come a long way since the Higgs boson discovery in 2012. It looks like the SM Higgs boson, it couples like the SM Higgs boson,…?

The Higgs boson might be key to answering **many open questions**



Not even close!

⇒ Keep investigating with better precision and granularity, probing rarer processes, more extreme phase-spaces, etc.

⇒ In the following, trying to give an overview over current best knowledge and most recent results - strong & personal selection!

Stony Brook University

Recent news on Higgs-fermion interactions

ttH(→bb): ATLAS final Run-2 [HIGG-2020-24]

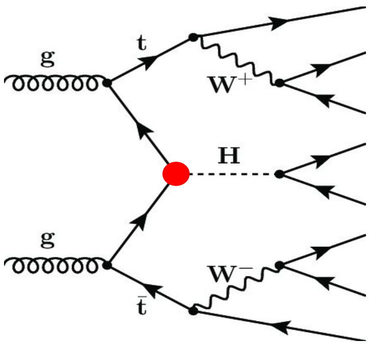
Stony Brook University

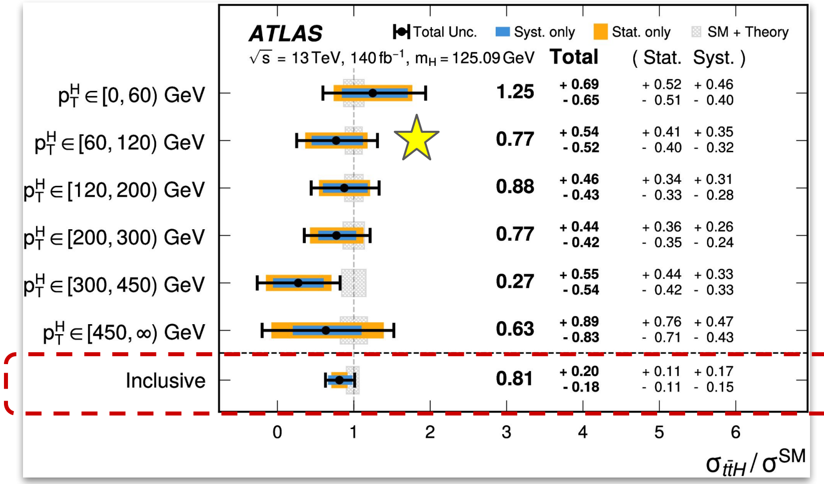
ttH: ~1% of all Higgs events; **most sensitive, direct probe of Higgs-top quark coupling**

1/2 leptons (e/μ)

H→bb: dominant decay

⇒ ideal for rare/extreme phase space





Extremely difficult final state:

- reco/ID of 4 b-jets and Higgs candidate
- suppression and modelling of di-top + b-jets background (and others)

⇒ Improved in re-analysis of JHEP 06 (2022) 97

Best single measurement to date!

Obs. (exp.) sign. 4.6 (5.4)σ

Uncertainty ~halved ; increased granularity.

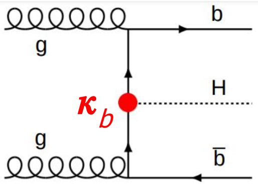
⇒ Consistent with SM prediction - up to high energy! (Does not confirm the ~2σ lower-than-expected previous ATLAS & CMS results (HIG-19-011))

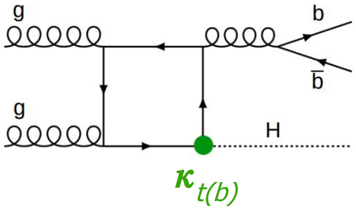
bbH: first SM search by CMS [HIG-23-003]

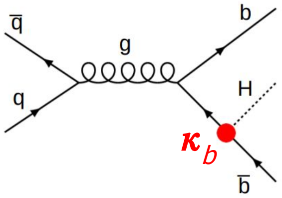
bbH cross-section ~ ttH cross-section

but experimentally even more challenging;

large backgrounds from Z+jets, tt, jet $\rightarrow \tau_{had}$ mis-ID



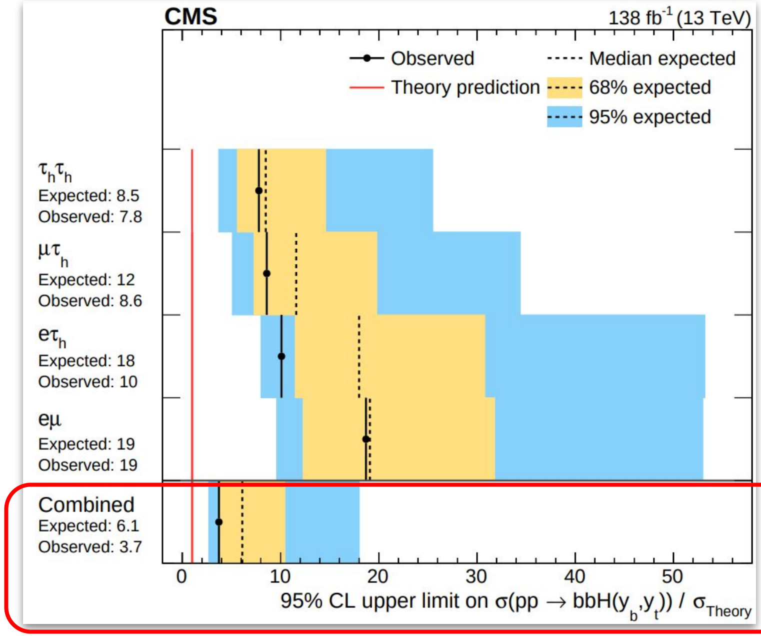




Sensitive to Higgs-b-quark *and* Higgs-top-quark coupling

(quark loop dominates XS + destructive interference)

H→leptons

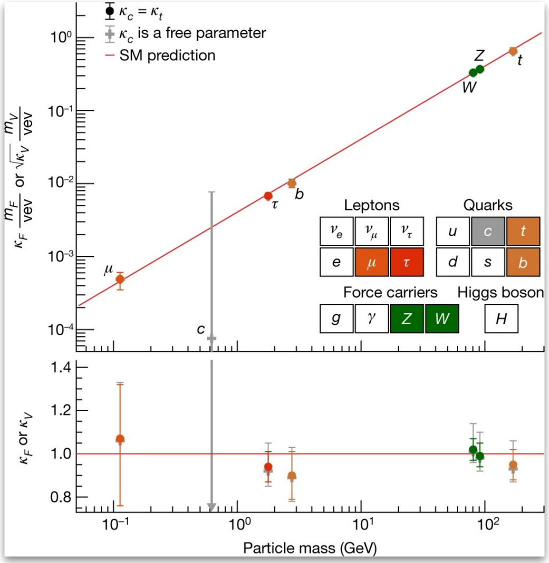


First upper limit

- combined with Eur. Phys. J. C 83 (2023) 562 (ggF+VBF $H \rightarrow \tau_{had}\tau_{had}$) and interpreted in terms of κ_t - κ_b

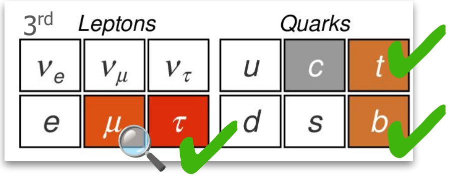
Higgs-fermion couplings beyond the 3rd generation

Status 2022



First time!

Fermion generations



✔**Observed**

$y_f \sim m_f$

- free parameters of the SM (9 out of 19)

⇒ **ALL Yukawa couplings need to be probed**

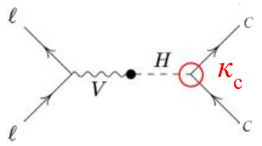
- the frontier lies at the charm quark

Many routes for probing κ_c

Some approaches can be used/adapted to probing light-quark couplings* (+ **HH production** [JHEP11(2019)088])

Via the decay

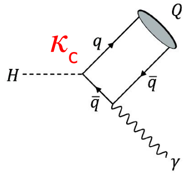
Inclusive H→cc



or VBF,... production

Exclusive H→Qγ*

[idea: Phys. Rev. D 88, 053003]



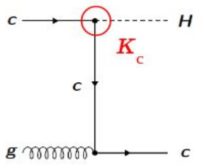
And more…

Assumptions and sensitivity to $\boldsymbol{\kappa}$ are very different.

Via the production

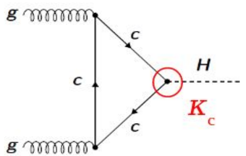
H+c [arXiv:2407.15550]

[idea: Phys. Rev. Lett. 115 (2015) 211801]

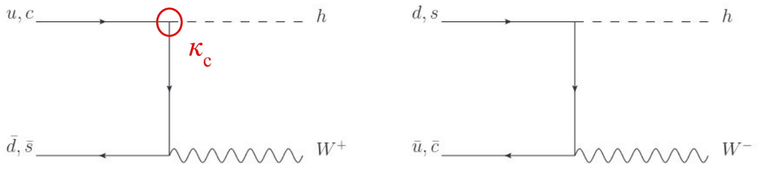


Higgs p_T spectrum*

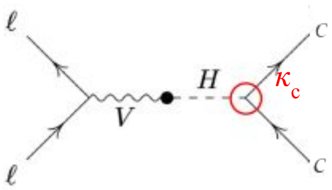
[idea: Phys. Rev. Lett. 118 (2017) 121801]



$W^{\pm}$H charge asymmetry* [idea: JHEP 02 (2017) 083]



VH(→cc): ATLAS final Run-2 [ATLAS-CONF-204-010]



V=W/Z

Z→ee/μμ/νν

W→eν/μν/τ_{had}ν

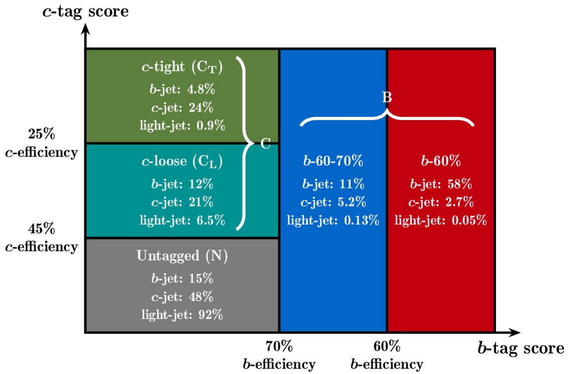
H→cc: 2.9% - largest BR to 2nd gen. fermions; 2nd largest BR not yet observed

⇒ **most direct & sensitive probe of Higgs-charm coupling**

V(→leptons)H: golden channel for H→bb/cc

Significant XS + effective multi-jet background suppression

Main challenges: c-jet identification (c-tagging); suppression and modelling of overwhelming V+jets (and top) backgrounds



New pseudo-continuous b-/c-tagger

⇒ Improved in re-analysis of Eur. Phys. J. C 82 (2022) 717:

⇒ **Best upper limit on VH(→cc): < 11.3** (10.4) **× SM** (exp.) @95% CL

⇒ **Most stringent direct constraint on κ_c: < 4.2** (4.1 exp.) @95% CL

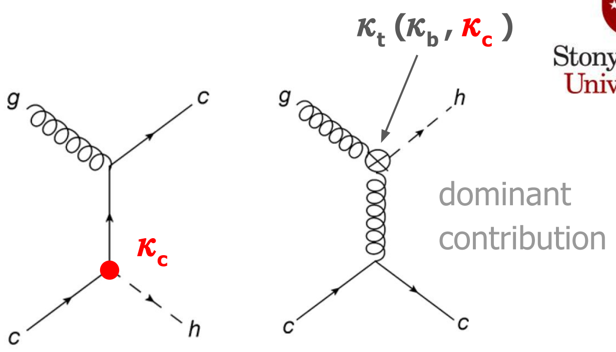
⇒ Higgs-charm coupling is weaker than Higgs-bottom coupling @99.7% CL

⇒ ***×2-3 improvements over previous result on the same dataset!***

⇒ **simultaneous analysis of VH, H→bb and H→cc!**

Similar result obtained by CMS [PRL 131 (2023) 061801]

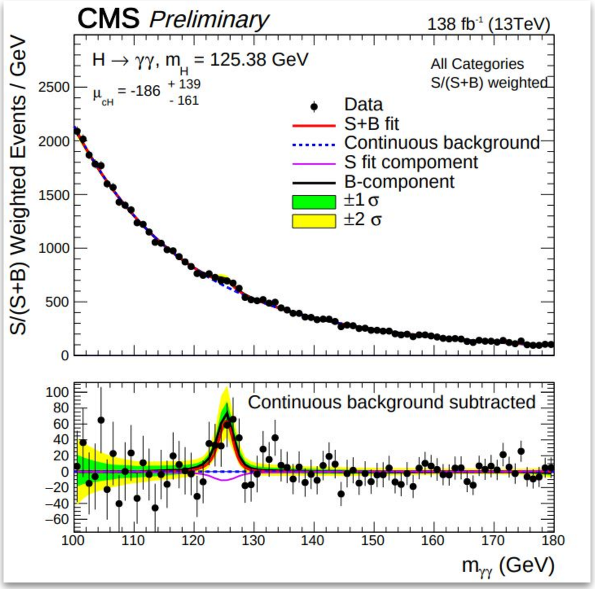
H+c: first search by ATLAS & CMS



First proposed in PRL 115 (2015) 211801.
SM XS: ~2.9 pb

Pros: exploit clean decay, e.g. H→γγ
Cons: c-tagging, dominant diagram *not* sensitive to κ_c (~99%)

ATLAS [HIGG-2021-06]
1.7σ (1.0σ) obs. (exp.) H+c over B-only hypothesis
⇒ **Upper limit on incl. H+c cross-section @95% CL: < 10.4 pb**
*[< 3.6 × SM $\xrightarrow{1\%}$ κ_c - sensitive: < 366 × SM]



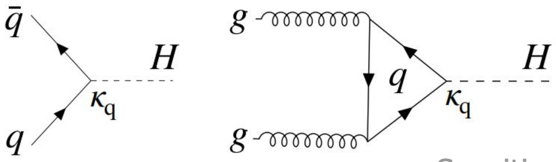
CMS [HIG-23-010]
Upper limit on κ_c - sensitive H+c cross-section:
< 243 (355 exp.) **× SM** @95% CL
Constraint on κ_c : < 38.1 (72.5 exp.) @95% CL

*HA's "interpretation"

CMS: Probing the light-quark Yukawa [HIG-23-011]

Stony Brook University

First time.
In inclusive H→ZZ* →4l production.



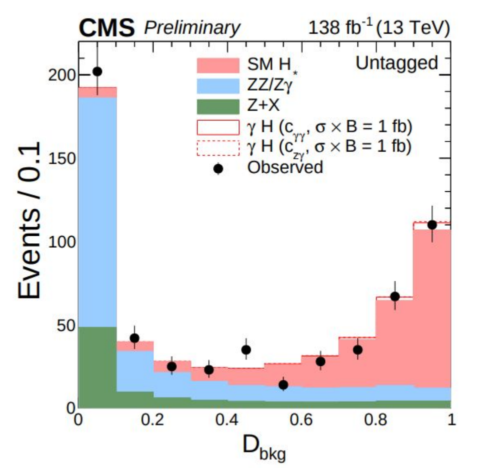
Sensitive production modes

Higgs-quark coupling κ_q affects the production and total decay width (but not the BR)

⇒ **Total cross-section monotonically decreases with increasing (κ_q)^2** (until it becomes incompatible with the data)

⇒ **Simultaneous constraints on κ_q for q = u, d, s, c**

⇒ **Assuming SM couplings for b and t, exclude light-quark couplings of at least as strong** @95% CL



ME-based discriminant using kinematic decay information

Higgs-boson total width

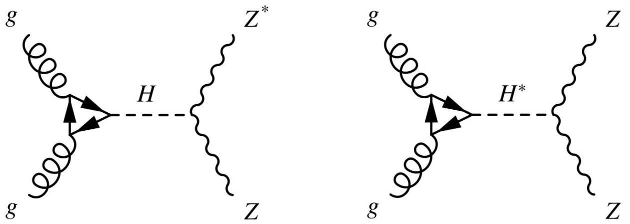
Stony Brook University

Assuming SM: Γ_H = 4.1 MeV for $m_H \sim$ 125 GeV

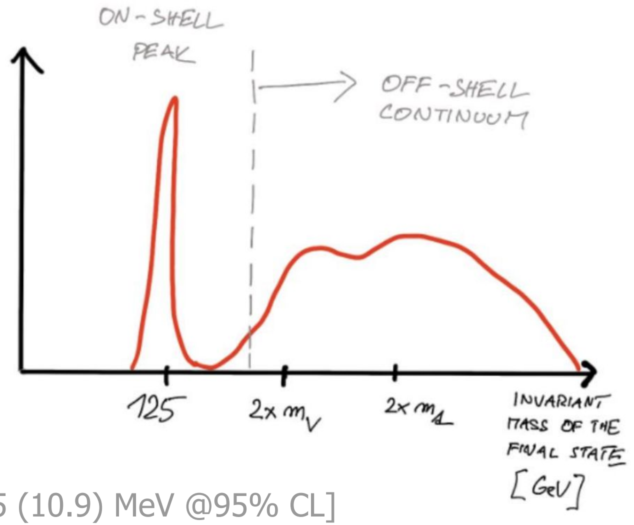
⇒ Constrain unmeasured/able decays?

⇒ **Modified through beyond-the-SM Higgs-boson decays?**

E.g. decays to dark-matter particles



At the LHC, **SM Γ_H inaccessible via direct measurements** of the Higgs-boson line shape or flight distance, due to limited detector resolution.



Credit: ATLAS off-shell team

⇒ Constrain via $\Gamma_H \propto$ σ(off-shell) / σ(on-shell)

Assumption: involved couplings are the same off-shell and on-shell

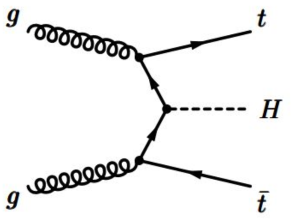
ggF H→ZZ$^{(*)}$→4l

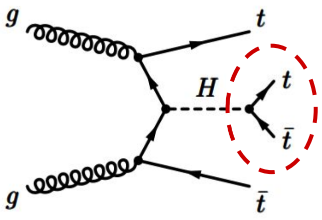
ATLAS: $\Gamma_H = 4.5^{+3.3}_{-2.5}$ MeV [PLB 846 (2023) 138223] [(exp.) upper limit: < 10.5 (10.9) MeV @95% CL]

CMS: $\Gamma_H = 3.0^{+2.0}_{-1.5}$ MeV [HIG-21-01]

Higgs-boson total width - ttH & tttt (ATLAS) [TOPQ-2023-22]

Stony Brook University





On-shell ~ $1/\Gamma_H$

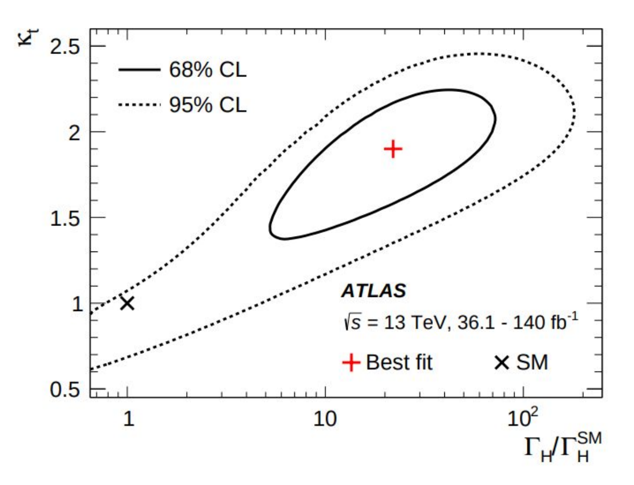
Off-shell

From global Higgs combination (- ttH multilepton).
All other κ are profiled →degeneracy with Γ_H
[Nature 607 52 (2022)]

From tttt cross-section measurement
[Eur. Phys. J. C 83 (2023) 496]

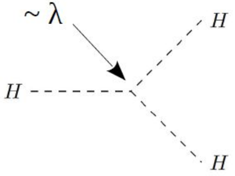
tttt is observed with 6.1σ (4.3 exp.)

Assumption: tree-level Higgs-top coupling, κ_t, is the same
[Pro: no loops w/ potential BSM couplings]



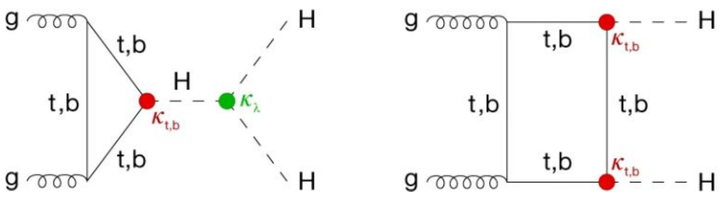
⇒ Γ_H < 110 (18 exp.) × SM
and < 39 (13.4 exp.) × SM if resolving ggF loops in terms of κ_t

Higgs-boson self-coupling & HH production

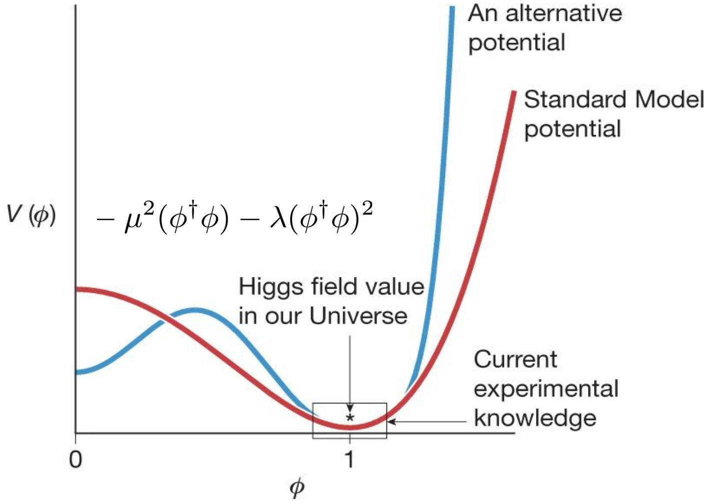


$m_H = \sqrt{2\lambda}\, v \quad \Rightarrow \quad \lambda \simeq 0.13$ in the SM

⇒ Direct access via HH production (~ 1/1000 × σ(H))*:



Dominant HH production diagram is *not* sensitive to κ_λ
+ destructive interference
[ggF dominant mode (90%), followed by VBF (5%)]



⇒ Probing the shape of the Higgs potential

Adapted from G. Salam et. al, Nature 607, 41 (2022)

[*And to quartic coupling via HHH]

ATLAS full Run-2 HH combination [PRL 133 (2024) 101801]

Small cross-section ⇒ prioritise final states with high BR: H→bb/VV (58%/24%)

"Cleanliness" also matters for the sensitivity

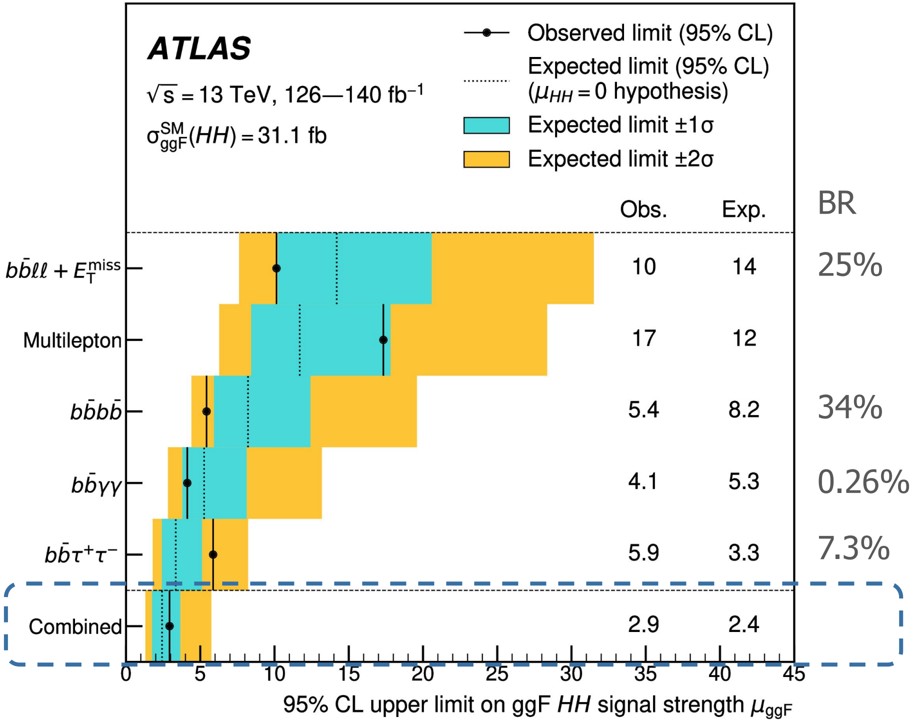
Hierarchy of channels depends on many things
⇒ not the same in ATLAS/CMS

Best (exp.) upper limit on σ(ggF HH):

< 2.9 (2.4) × SM @95% CL

⇒ Most stringent constraint on self-coupling:

-1.2 < κ_λ < 7.2 (-1.6 < κ_λ < 7.2 exp.) @95% CL

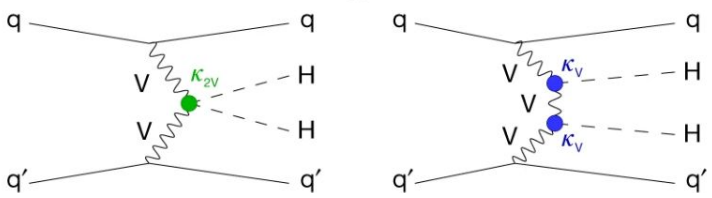


Similar result obtained by CMS [Nature 607 (2022) 60].

bbll+ETmiss = WW/ZZ/ττ
Multilepton = 4τ/2τ2γ/2τ2V/4V

HHVV couplings - from HH

HH is also sensitive to other couplings, notably HHVV (κ_{2V})



In SM (κ_{2V} = 1): cancellation; new physics: potential enhancement of VBF HH (esp. at high m_{HH})

Current best constraint by CMS [Nature 607 (2022) 60]:

0.67 < κ_{2V} < 1.38 @95% CL

κ_{2V}=0 excluded with > 6σ

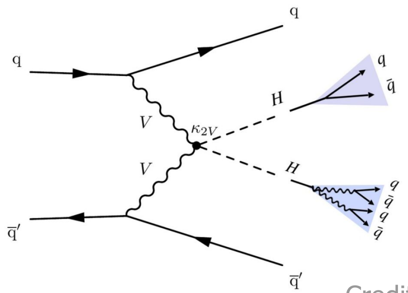
From VBF HH combination; dominated by **boosted 4b** channel.

Similar result obtained by ATLAS [PRL 133 (2024) 101801].

CMS - new final state: all-hadronic bbVV

boosted topology + new VV→4q tagging

[HIG-23-012]



Credit: N. Berger

-0.04 < κ_{2V} < 2.05 @95% CL

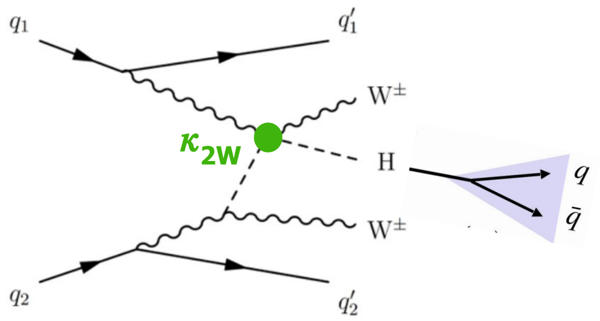
(0.05 < κ_{2V} <1.98 exp.)

κ_{2V}=0 excluded with 1.1(0.9)σ

HHVV couplings - from VBS H (CMS) [HIG-24-001]

Stony Brook University

First analysis probing the HHVV ~ HHWW (κ_{2W}) coupling in $W^{\pm}W^{\pm}H$ events produced in vector boson scattering (VBS)



boosted H→bb
+ 2 jets with mjj > 100 GeV
+ 2 same-sign leptons

⇒ **Obs.** (exp.) **constraint on κ_{2W}: [-3.3,5.4]** ([-2.4,4.4])

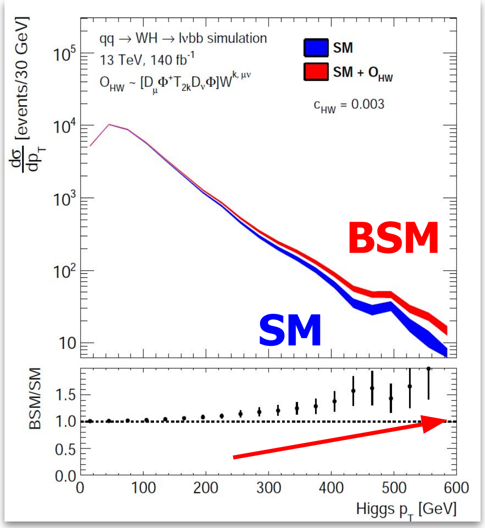
⇒ **Can be applied to other modes!**

Studying the Higgs-boson's kinematics

Stony Brook University

The large Run-2 dataset allows **differential measurements of the Higgs-boson cross-section** as function of one or more kinematic variables to

- Reveal subtle deviations from the SM prediction
- Probe certain properties with enhanced sensitivity
- Improve MC simulations
- …



<u>Two types of differential measurements</u>:

- Unfolded fiducial differential measurements
- Simplified Template Cross-Sections (STXS)

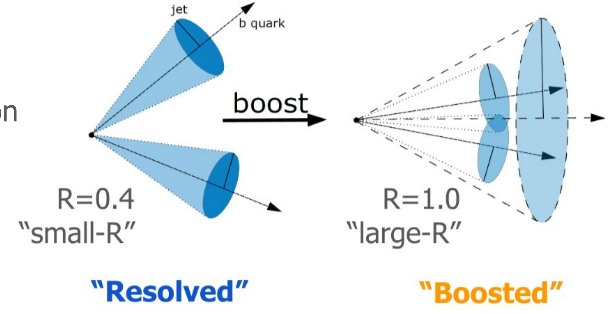
  "unfolding" only the production, designed for combinations across different Higgs-boson decay modes (harmonised across ATLAS and CMS within LHC Higgs WG)

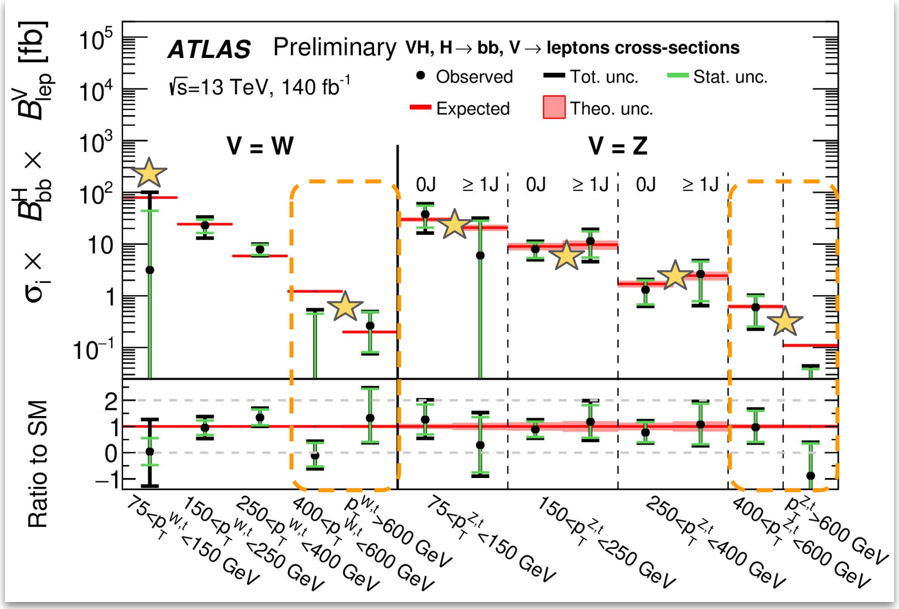
  - First study of a simplified fiducial *decay* selection for H→4ℓ to reduce acceptance corrections for potential BSM contributions [ATL-PHYS-PUB-2023-033]

ATLAS V(→leptons)H(→bb) STXS [ATLAS-CONF-2024-010]

Most granular and precise STXS measurement of VH

H→bb reconstruction





6 new (split) bins and increased precision through re-analysis of ATLAS-CONF-2021-051 with many, targeted analysis improvements

Bonus: first WH(→bb) observation with 5.3σ (5.5σ exp.)

Increasing $p_T(V) \sim p_T(H)$ - **unprecedent reach!**

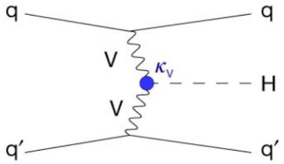
⇒ **Excellent agreement with SM up to highest energy** (Overall SM compatibility: 90%.)

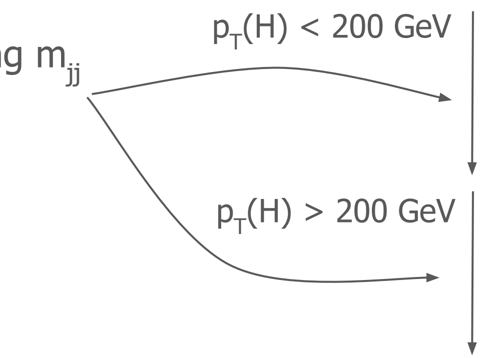
ATLAS (VBF) H→ττ STXS measurement

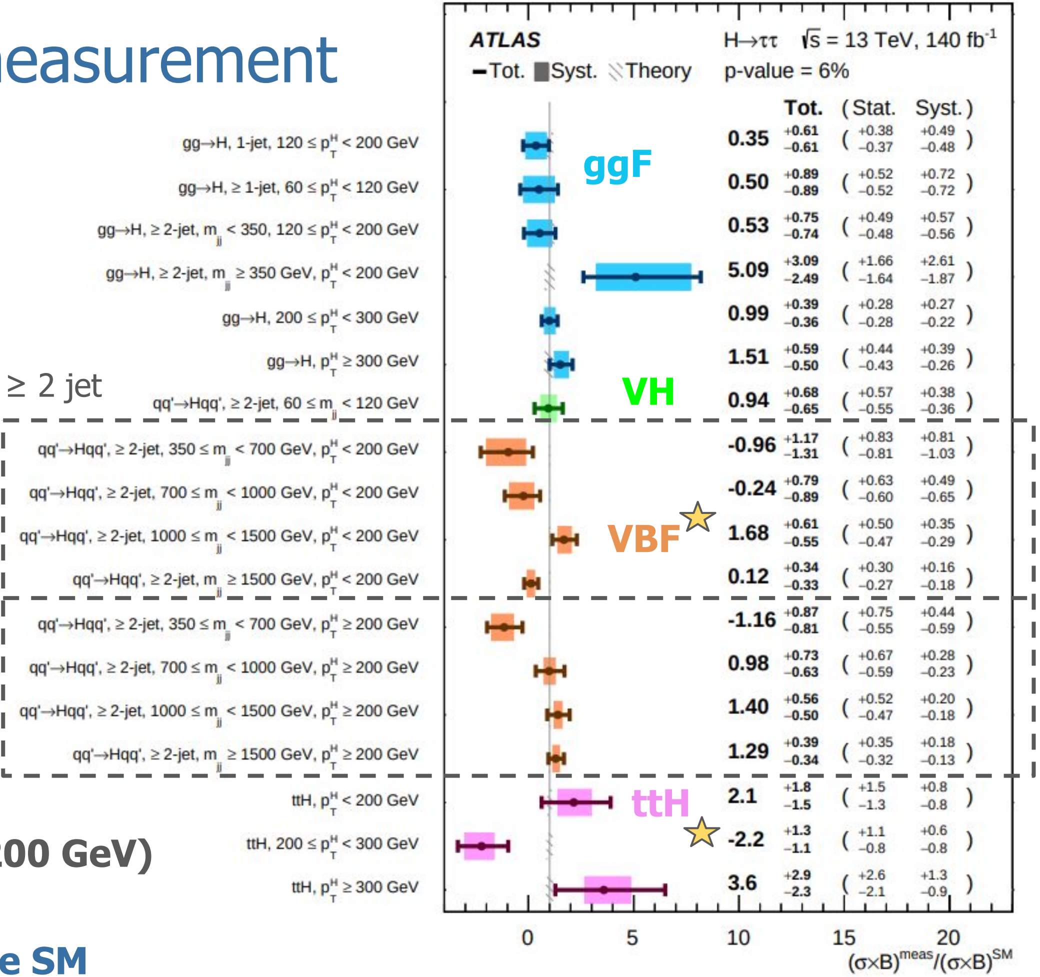
[HIGG-2022-07]

JHEP 08 (2022) 175 most precise inclusive VBF measurement

⇒ Re-analysis for differential measurement



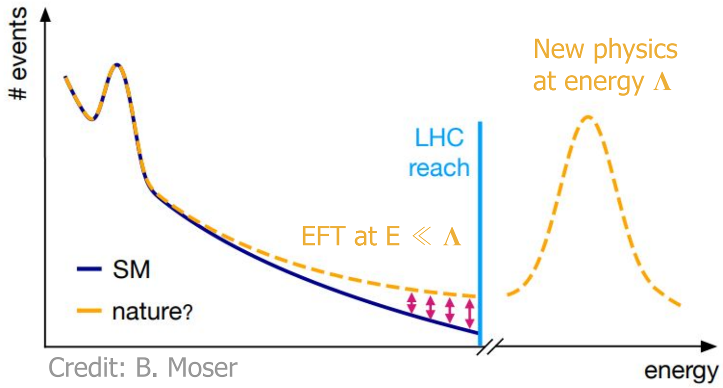




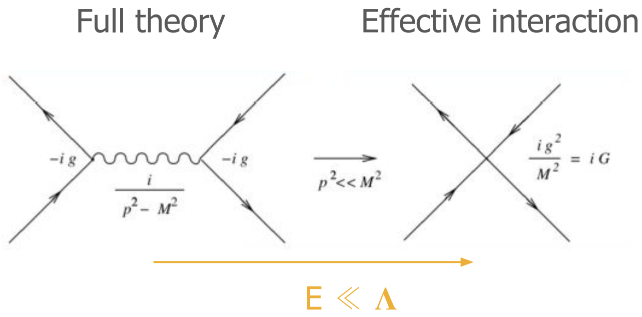
First (most precise) VBF measurement for m_{jj} > 1.5 TeV in $p_T(H)$ > 200 GeV (< 200 GeV)

⇒ Overall reasonable agreement with the SM

Interpretation: SMEFT



Credit: B. Moser



Standard Model Effective Field Theory (SMEFT)

⇒ **model-independent** way to parametrise effects of **new physics** appearing at high energy Λ ($\gg$ vev) at much lower energy ($E \ll \Lambda$)

$$\mathcal{L}_{eff} = \mathcal{L}^{SM} + \mathcal{L}^{D=6}, \qquad \mathcal{L}^{D=6} = \frac{1}{\Lambda^2}\sum_i c_i^{(6)} \mathcal{O}_i^{(6)}$$

O_i: operators built from SM fields and respect SM symmetries

c_i: Wilson coefficients ~ strength of the effective interaction (SM: 0)

⇒ **Observables**, e.g. cross-section

BSM~$1/\Lambda^4$ ⇒"quadratic"
[same as dim-8!]

$$\sigma_{\rm STXS} = \sigma_{\rm SM} + \sigma_{\rm int} + \sigma_{\rm BSM}$$

SM-BSM interference ~$1/\Lambda^2$ ⇒"linear"

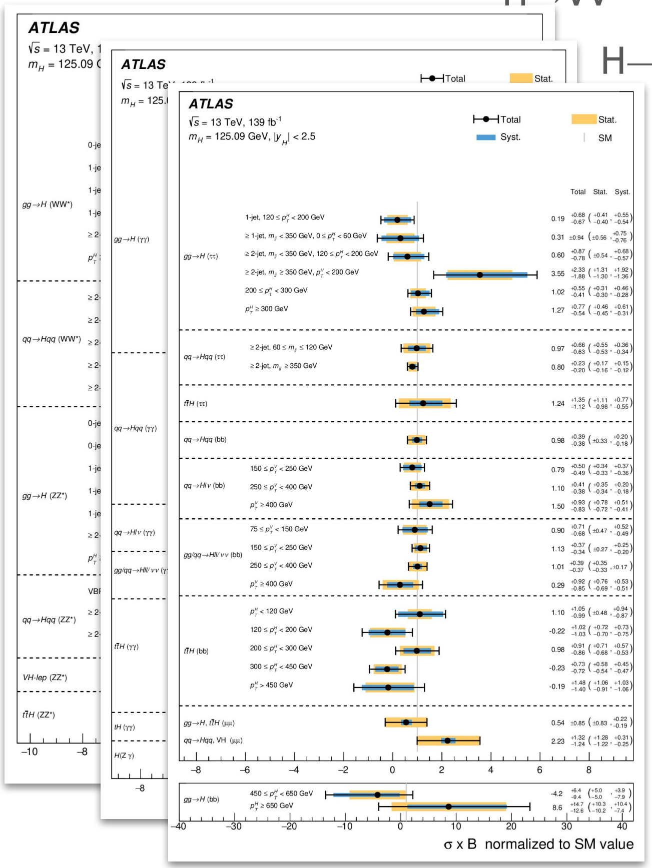
Interpretation of ATLAS STXS measurements [HIGG-2022-17]

H→VV

H→γγ

H→ττ/bb/μμ

Production modes



STXS binning: $p_T(H)$ or $p_T(V)$ (and m_{jj} for ggF/VBF)

⇒ Sensitive to O(50) SMEFT operators O_i*

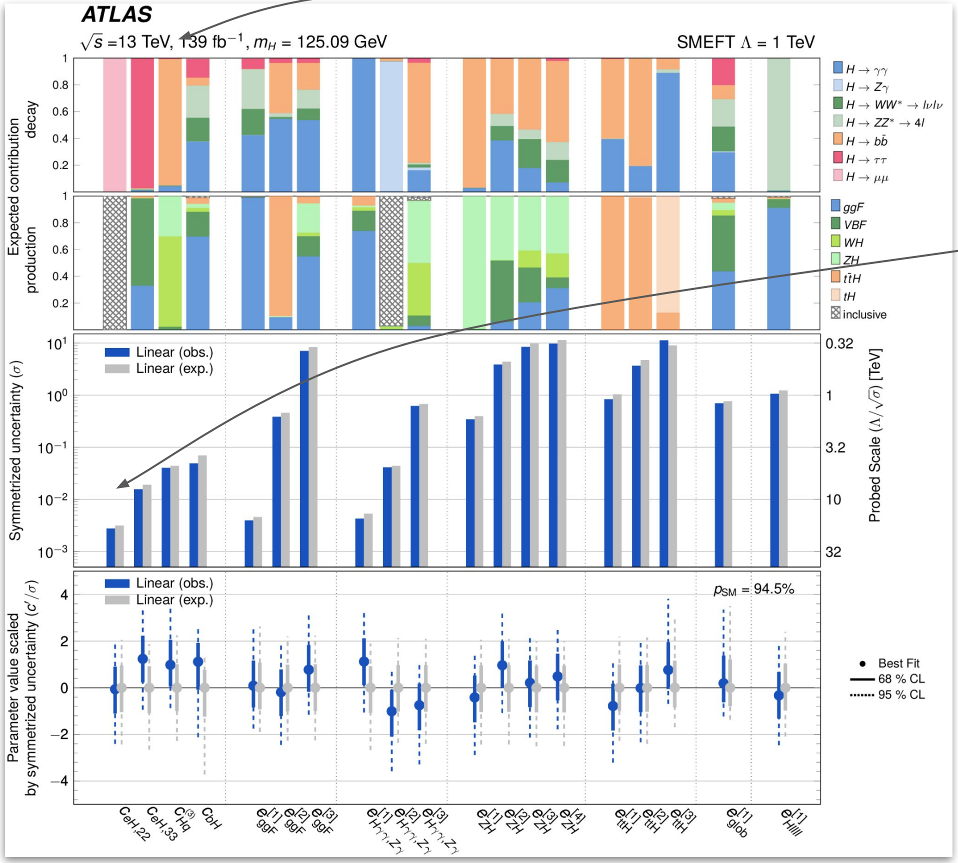
Data insufficient to constrain all corresponding Wilson coefficients c_i simultaneously

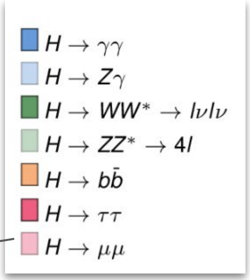
⇒ Principal Component Analysis (PCA) ⇒ Linear combinations of Wilson coefficients e_j

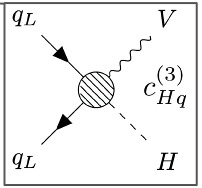
⇒ Constrain a subset of 19 coefficients or linear combinations of coefficients where necessary

*Only considering CP-even

Interpretation of ATLAS STXS measurements [HIGG-2022-17]







Mostly constrained by VH, H→bb

Constraints in the linearised model
- considering quadratic terms generally improves the constraints on the coefficients (esp. at a scale of 1 TeV).

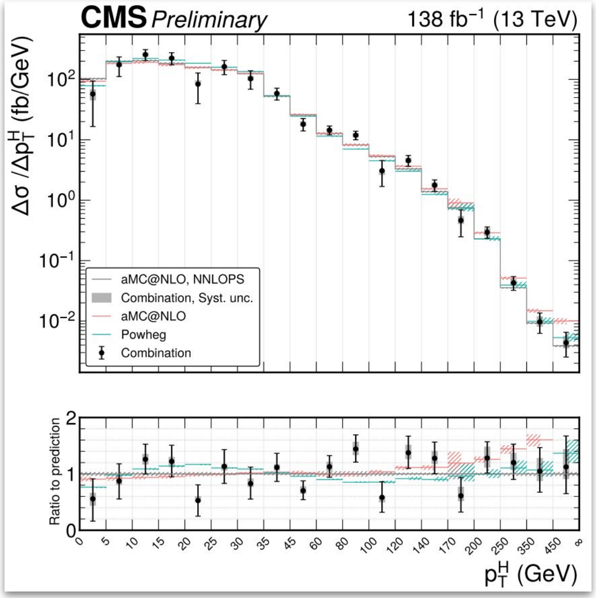
SM compatibility: 94.5% (98.2% for +quad.).
⇒ **Good agreement with SM prediction (c_i=0)**

Interpretation of CMS fid. diff. XS measurements [HIG-23-013]

Stony Brook University

Combination of fiducial differential cross-section measurements in H→γγ / $\tau\tau$ / WW / ZZ final states.

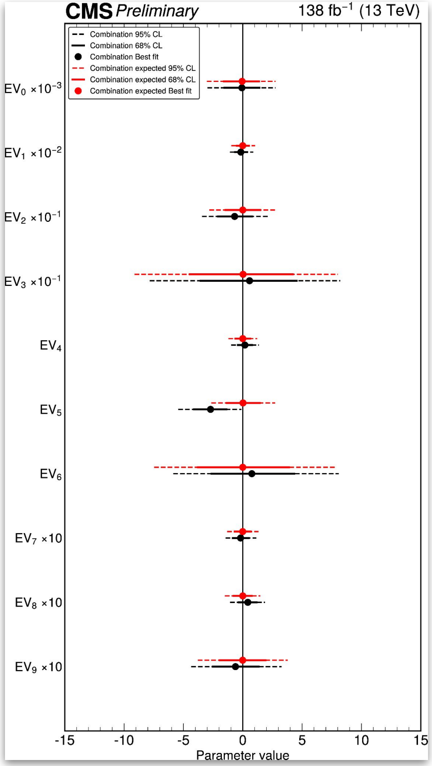
Measured observables: $\mathbf{p_T(H)}$, N_{jets}, y(H), lead. $p_T(j)$, m_{jj}, $\Delta\eta_{jj}$, $\tau_C^{\,i}$



SMEFT interpretation →

31 Wilson coefficients
⇒ PCA ⇒ 10 EVs

+2D scans of **pairs of CP-even and CP-odd** Wilson coefficients



Decreasing constraining power

Good agreement with the SM (i.e. 0)

Linear+quad. parametrization

Intermezzo: Higgs CP and CP violation

Stony Brook University

Explaining the matter-antimatter asymmetry in the universe requires **new sources of CP violation**
(CP violation in the SM does not suffice)

⇒ **CP violating Higgs-boson production or decay?**

The SM Higgs boson is a CP-even scalar (0^+).

ATLAS and CMS excluded *pure* spin-parity states 0^- , 1^+ , 1^- , 2^+ and 2^- @> 99% CL based on the observed Higgs boson decays ($\gamma\gamma$, ZZ, WW).

Still possible: Higgs boson is an ***admixture* of CP-even and CP-odd states** with CP-odd contributions to the CP-even dominated couplings resulting in CP violation in Higgs-boson production or decay.

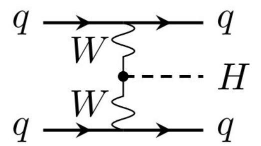
⇒ **Keep probing for CP-odd effects in Higgs-boson couplings (e.g. via SMEFT)**

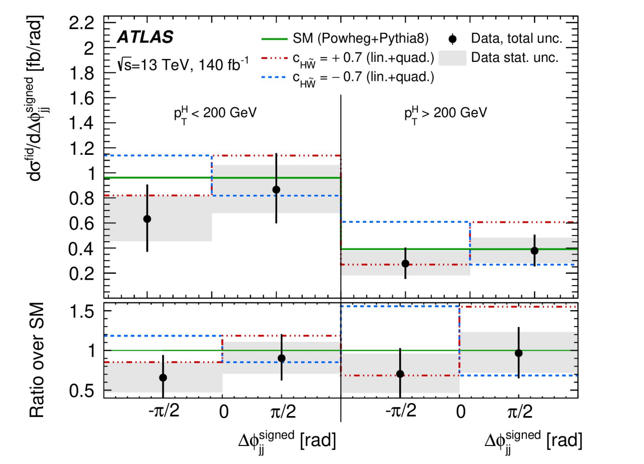
Interpretation of ATLAS VBF $H\rightarrow\tau\tau$ XS measurement

[HIGG-2022-07]

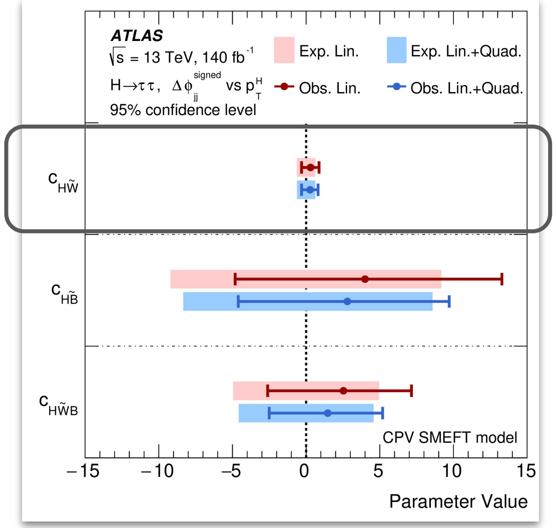
Fiducial (double) differential cross-section measurements in $p_T(H)$, lead. $p_T(j)$, and signed $\Delta\phi_{jj}$ and to **increase the CP sensitivity: signed $\Delta\phi_{jj}$ vs $p_T(H)$**

⇒ **Individual and 2D constraints on 3 CP-even (CP-odd) operators**

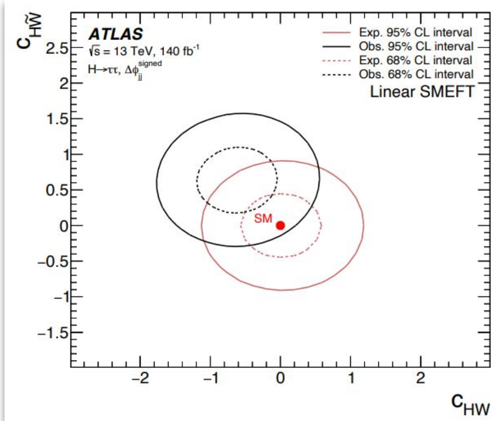




signed $\Delta\phi_{jj}$ vs $p_T(H)$



1D constraints on CP-odd operators



From signed $\Delta\phi_{jj}$ (linear)

CMS: SMEFT constraints from V(→leptons)(H→bb)

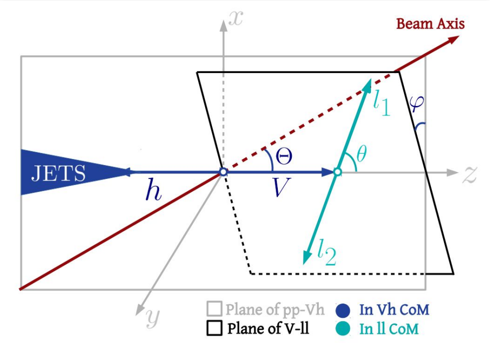
[HIG-23-016]

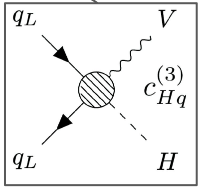
Analysis optimised to probing SMEFT effects: overcoming degeneracy in effects of different operators and adding sensitivity to CP properties (relative to STXS-based interpretation)

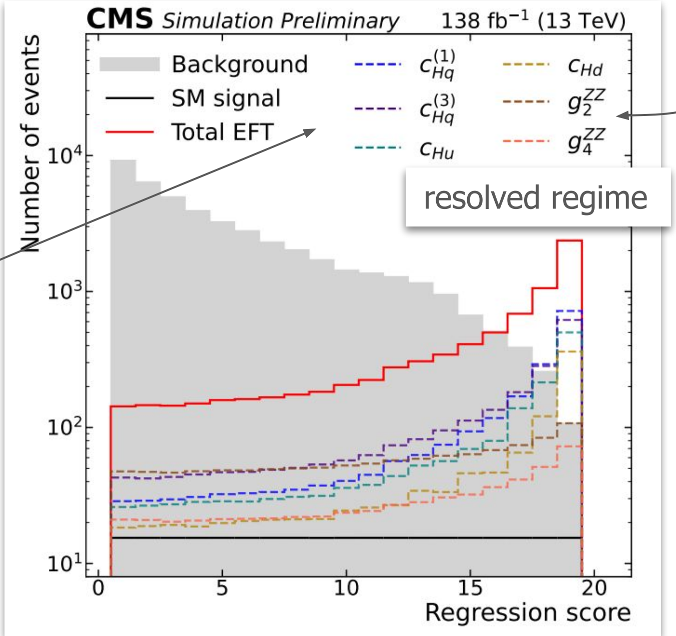
Linear combinations of CP-even/odd operators (through rotation to the mass-eigenstate basis)

Strategy:

- Likelihood-free inference method using boosted decision trees (boosted information tree, BIT)
- Set of EFT-sensitive and S/B-separating observables, e.g. $p_T(V)$, m_{VH}, angular distributions







CMS: SMEFT constraints from V(→leptons)(H→bb)

[HIG-23-016]

Analysis optimised to probing SMEFT effects: overcoming degeneracy in effects of different operators and adding sensitivity to CP properties (relative to STXS-based interpretation)

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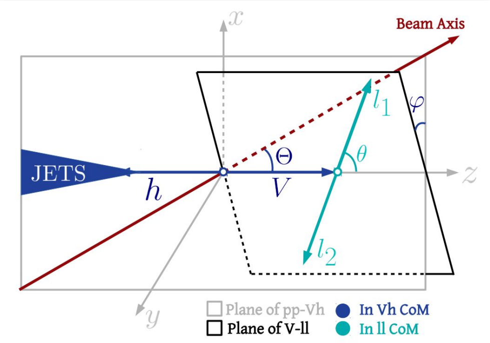

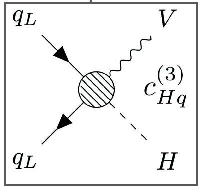

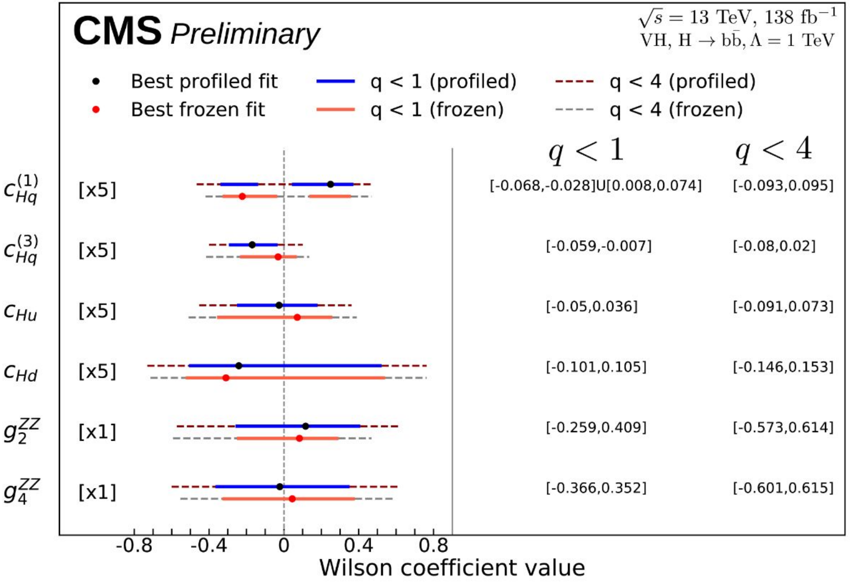

Excellent simultaneous sensitivity.

SM compatibility (profiled): 84%

Run-3 efforts are gaining momentum

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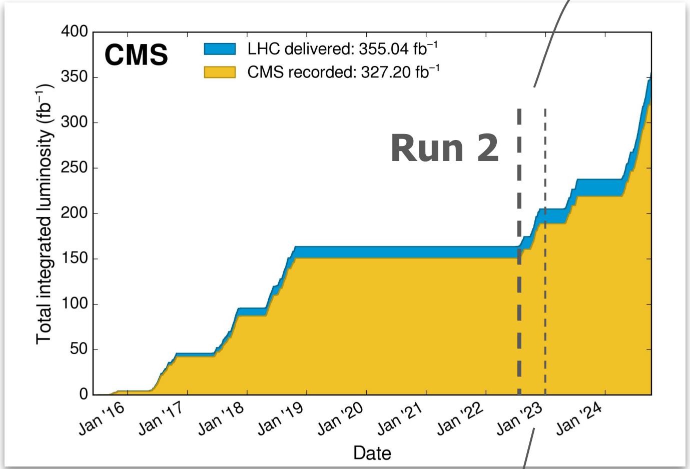
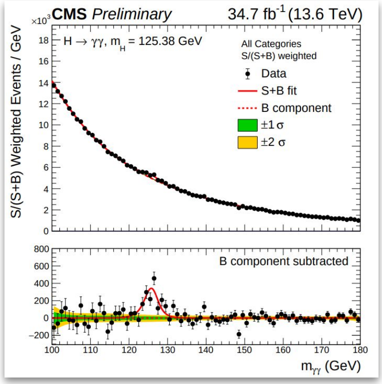
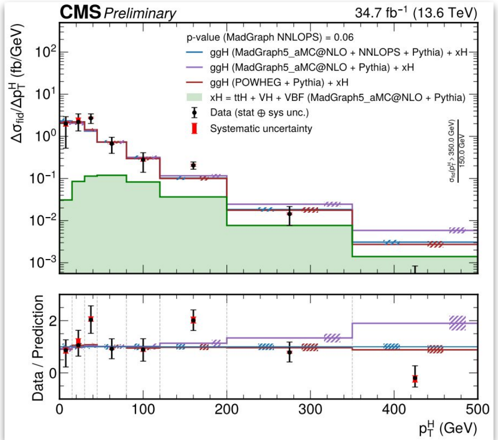
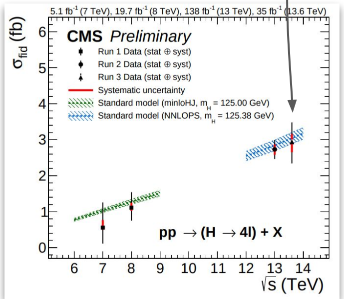


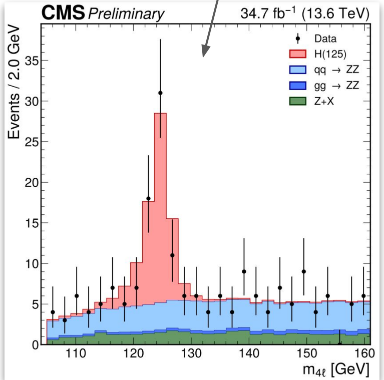


HIG-23-014



HIG-24-013



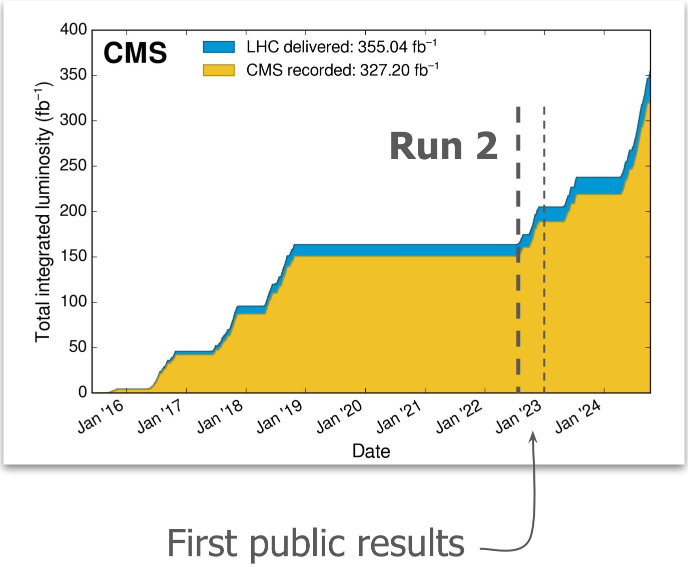


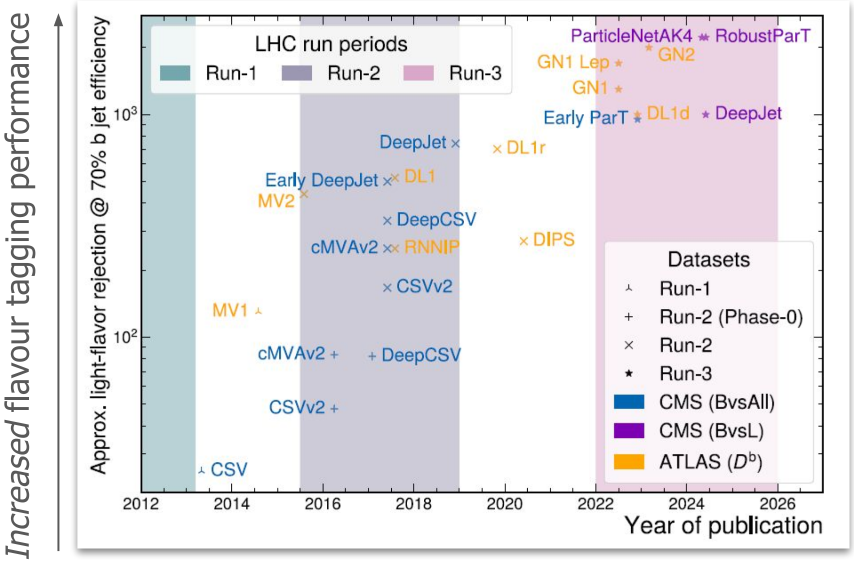
First (differential) cross-section measurements using 2022 data in H→ZZ*→4l and H→γγ by CMS.

Comparable results by ATLAS [Eur. Phys. J. C 84 (2024) 78].

⇒ **Good agreement with SM prediction**

Run-3 efforts are gaining momentum





Eur. Phys. J. Spec. Top (2024)

But already ~5× more data collect

Large progress in techniques in the past years, still improving quickly

⇒ Stay tuned for more Run-3 results!

Conclusions

Stony Brook University

ATLAS and CMS have been probing the predicted Higgs boson's properties and couplings to other SM particles more broadly and precisely than ever.

Highlighted some of the most recent results.

All results are consistent with the SM predictions, but plenty of unprobed areas where deviations are well-motivated to occur.

Focus is shifting to analysing Run-3 data. The increased dataset and new analysis techniques promise a new push of the current frontiers: Higgs-boson self-coupling, couplings to the second fermion generation, high-energy Higgs-boson production,...

We have exciting times ahead of us!

For more information

Stony Brook University

Parallel session on Tuesday

David Munoz Perez: “Measurements of Higgs boson properties (mass width and Spin/CP) with the ATLAS detector”

Lena Maria Herrmann: “Measurements of Higgs boson production and decay rates with the ATLAS experiment”

Tahir Javaid: “Higgs differential cross section and STXS measurements at CMS”

Parallel session on Wednesday

Bartlomiej Henryk Zabinski: “Probing the nature of the electroweak symmetry breaking with Higgs boson pairs in ATLAS”

…and more!