HIGGS HUNTING 2026

EFFECTIVE FIELD THEORIES – ATLAS

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ATLAS EXPERIMENT

ATLAS EFT: RECENT RESULTS

- EFT provides a common language to interpret measurements as constraints on possible BSM physics
- These slides showcase some recent ATLAS publications that use the EFT language:
  - Combination of Higgs boson measurements (arXiv:2608.07332)
  - Measurements of the Higgs boson production, fiducial and differential cross-sections in the four lepton decay channel (arXiv:2605.19016)
  - Combination of measurements of CP properties of Higgs boson interactions with vector bosons (arXiv:2603.20117)
  - Search for anomalies in VBF production of the Higgs boson in $H(\rightarrow \gamma\gamma)jj$ (arXiv:2603.20087)
  - Effective field theory interpretation of ATLAS measurements involving the Higgs boson, electroweak bosons and the top quark (arXiv:2604.21670)
  - Effective field theory interpretations of the search for HHbbyy (ATL-PHYS-PUB-2025-034)
- All use SMEFT in the Warsaw basis, except when specified otherwise

HIGGS COMBINATION

arXiv:2608.07332

- Combination of Higgs measurements using up to 140 fb^{-1} of data, collected in 2015-18 at 13 TeV
- The inclusive Higgs boson event rate relative to its Standard Model prediction is determined to be $0.990^{+0.053}_{-0.051}$
- Inclusive production cross-sections and decay branching ratios are measured, with sensitivities improved by up to 35% relative to the previous ATLAS publication.
- Also interprets 116 simplified cross-section template (STXS) inputs in 44 kinematic regions for SMEFT.
- More about this combination in Matt Basso's talk from yesterday
- I will focus on the SMEFT interpretation

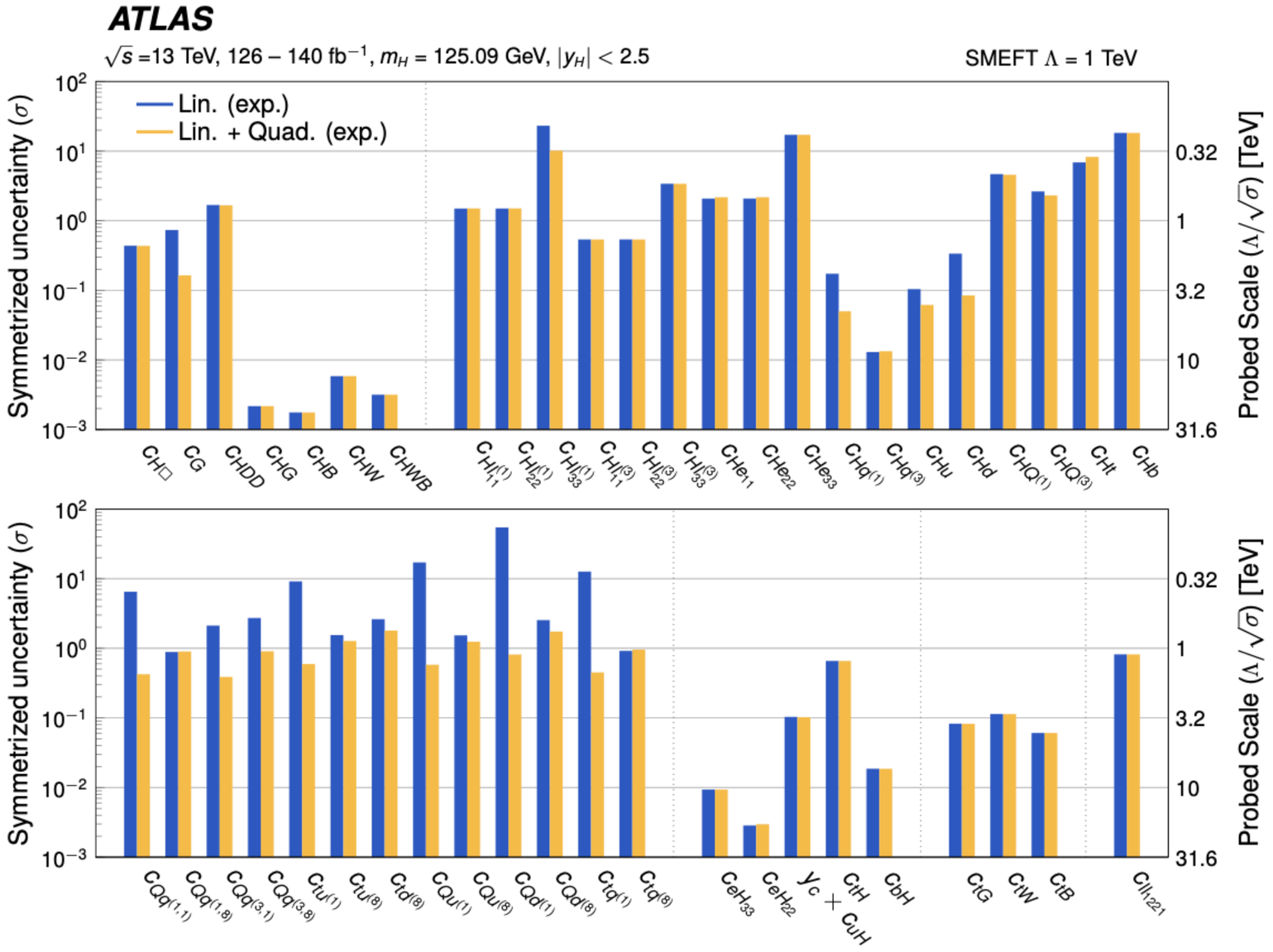
List of analyses included in the combination

Analysis	Prod. modes	$\mathcal{L}$ [fb^{-1}]
$H \to ZZ^* \to 4\ell$	All	140
$H \to WW^* \to \ell\nu\ell\nu$	ggF, VBF	140
$H \to WW^* \to \ell\nu\ell\nu, \ell\nu jj$	VH	140
$H \to \gamma\gamma$	All	140
$H \to Z\gamma$	All	140
$H \to \tau\tau$	All, except $(V \to \text{leptons})H$	140
$H \to \tau\tau$	$(V \to \text{leptons})H$	140
$H \to \mu\mu$	All	140
$H \to bb$	VBF	126
$H \to bb, cc$	$(V \to \text{leptons})H$	140
$H \to bb$ (high p_{T}^H)	All	136
$H \to$ multileptons	ttH	140
$H \to bb$	ttH	140
$H \to bb$	tH	140
$H \to$ invisible	VBF	140
$H \to$ invisible	VBF + γ	140
$H \to$ invisible	$(V \to \text{leptons})H$	140
$H \to$ invisible	ttH	140
$H^{(*)} \to ZZ^{(*)}$	ggF, VBF	140
$H^{(*)} \to WW^{(*)}$	ggF, VBF	140
$HH \to bbbb$	ggF, VBF	126
$HH \to bbbb$ (high p_{T}^H)	VBF	140
$HH \to bb\tau\tau$	ggF, VBF	140
$HH \to bb\gamma\gamma$	ggF, VBF	140
$HH \to bb\ell\ell + E_T^{\text{miss}}$	ggF, VBF	140
$HH \to$ multileptons	ggF, VBF	140

HIGGS COMBINATION: WHAT EFT OPERATORS CAN WE ACCESS?

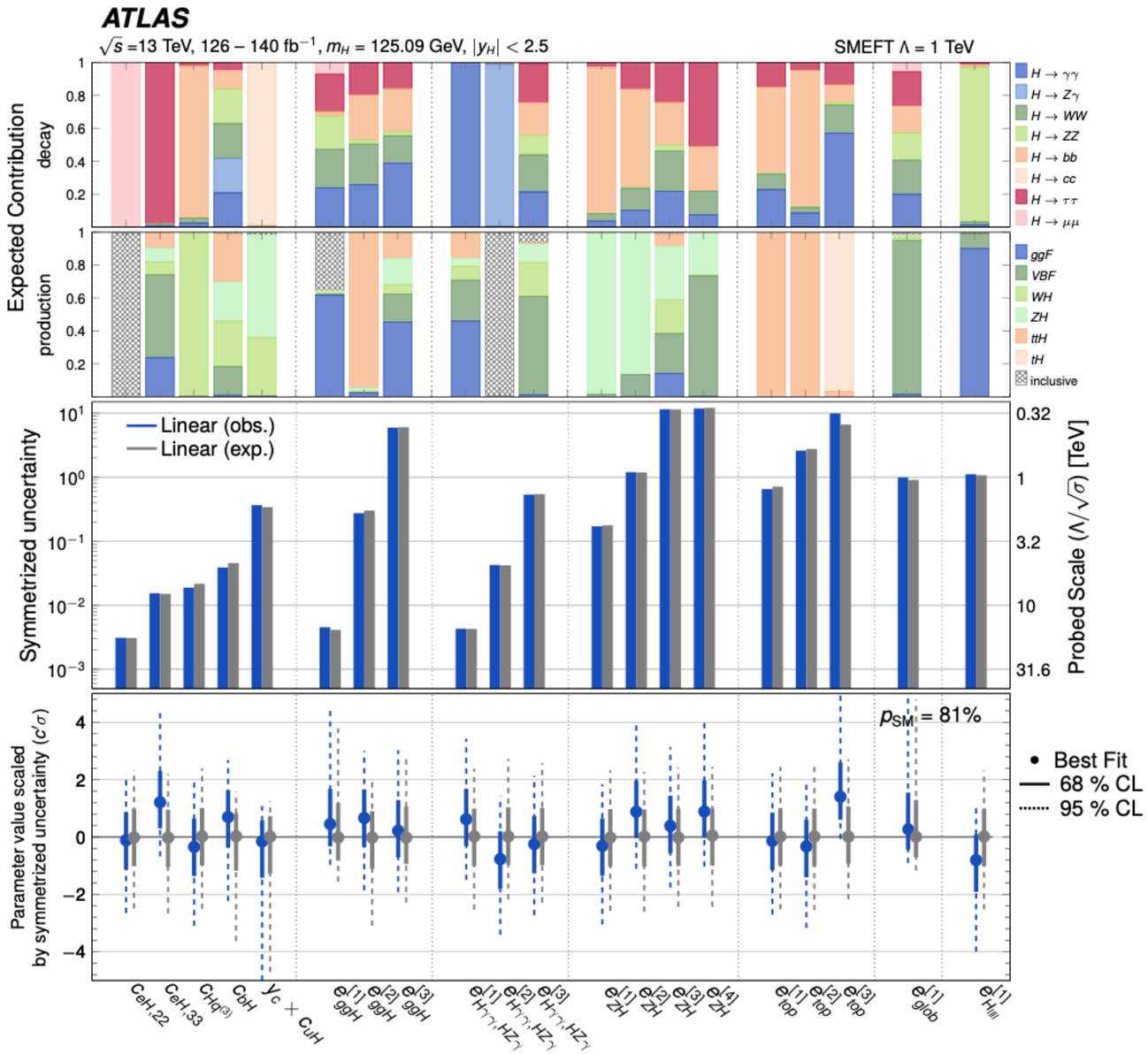
arXiv:2608.07332

- Higgs production and decay expressed in 46 dim-6 operators
  - Selected for CP-even operators with non-negligible impact
- Both linear and linear + quadratic parameterisations considered
- The sensitivity to individual EFT parameters is estimated by varying one parameter at a time
- Large variation in the results, expected uncertainties on individual EFT parameters span roughly 10^{-3} to > 10, corresponding to sensitivity scales up to 20 TeV



HIGGS COMBINATION: CONSTRAINTS ON EFT OPERATOR COEFFICIENTS arXiv:2608.07332

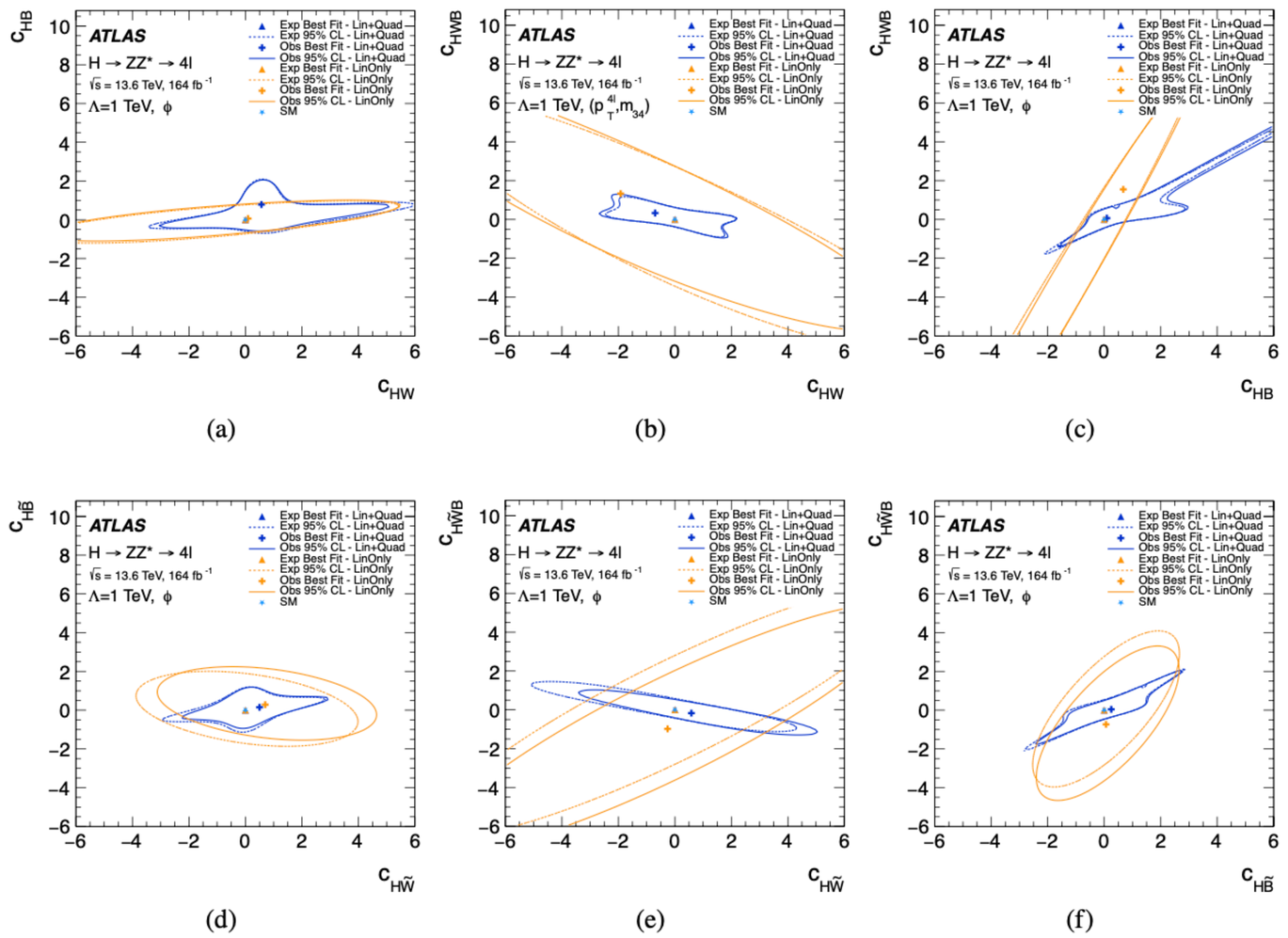
- Constraints not calculated on the full set, but first we identify the 20 experimentally accessible directions.
  - Unconstrained (“flat”) directions are removed.
- Complementary production and decay measurements constrain different EFT directions
- Uncertainty ranging from 10^{-2} to 10^{-3}, corresponding to a sensitivity to EFT scales ranging from 10 to 30 TeV
- This combination improves the constraints on several directions compared with previous ATLAS results
- All results are compatible with the SM



LATEST H4L RESULTS

arXiv:2605.19016

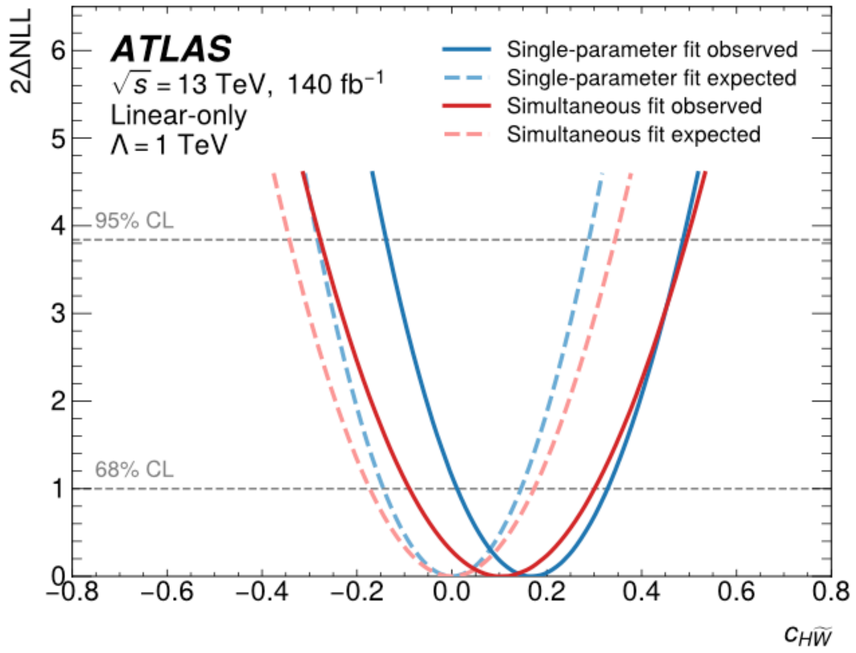
- Follow-up to arXiv:2004.03447 which is an input to the combination just shown.
  - Adding 164 fb^{-1} of data, collected in 2022-24 at 13.6 TeV
- The $H \to ZZ^* \to 4\ell$ channel provides a very clean final state. Differential and STXS measurements performed in the Higgs to 4l channel, here I focus on the interpretation with EFT.
  - More details in the talk from Elena Cuppini!
- Given the sensitivity in this channel, only three CP-even and three CP-odd operators modifying Higgs boson interactions with electroweak gauge bosons are probed

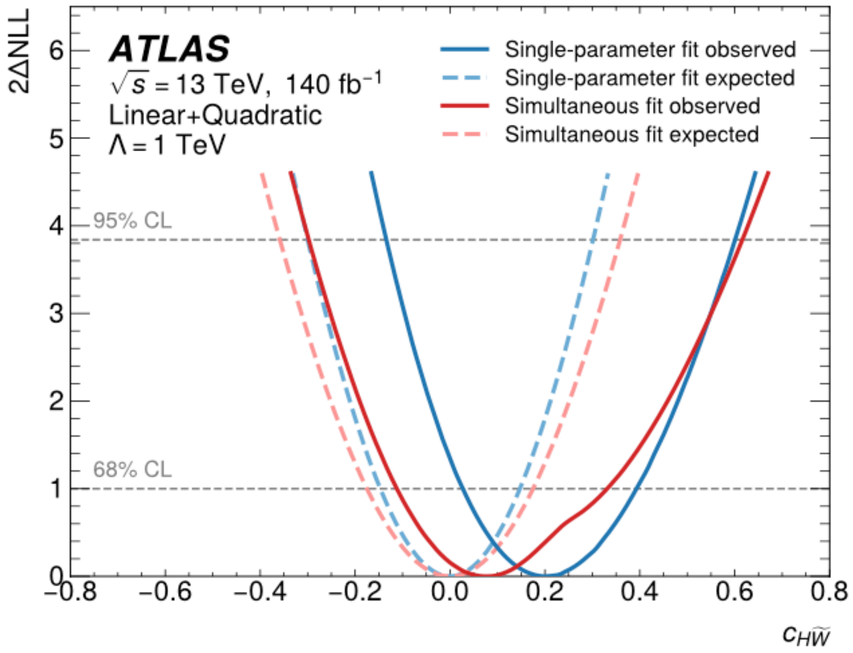


CP PROPERTIES OF HIGGS BOSON INTERACTIONS

arXiv:2603.20117

- Combination of Higgs CP measurements using up to 140 fb^{-1} of data, collected in 2015-18 at 13 TeV.
- Combines results from VBF $H \to \tau\tau/WW^*/\gamma\gamma$, inclusive $H \to ZZ^*$ and WH with $H \to b\bar{b}$
- The combination allows a more complete, less model-dependent test of the CP structure
- No evidence of CP violation is observed, and constraints are set on the dim-6 CP-violating operators in SMEFT
- Consider only CP-violating operators that conserve lepton and baryon number, and are non-trivial for HVV interactions: $c_{H\tilde{W}}$, $c_{H\tilde{B}}$ and $c_{H\tilde{W}B}$

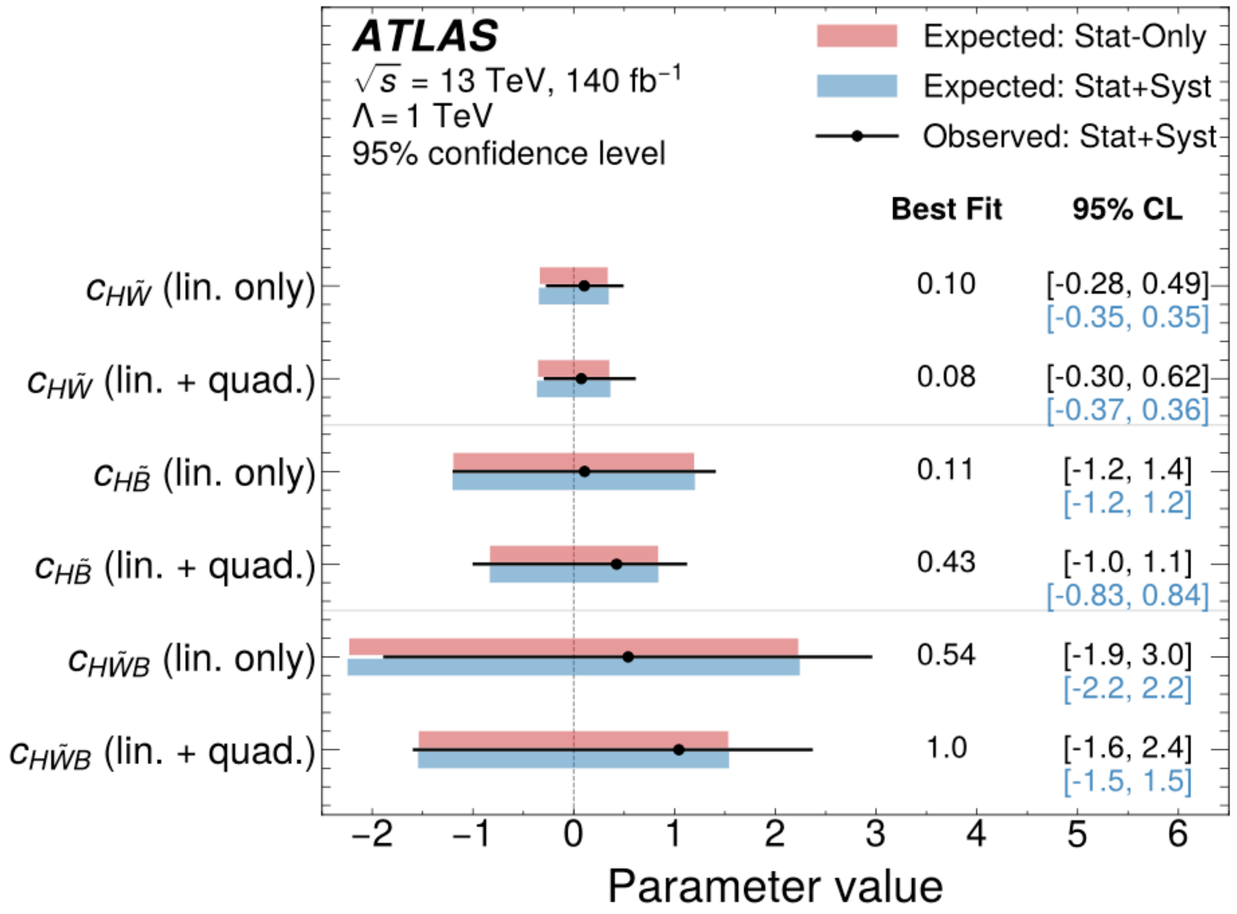




CP PROPERTIES OF HIGGS BOSON INTERACTIONS: RESULTS

arXiv:2603.20117

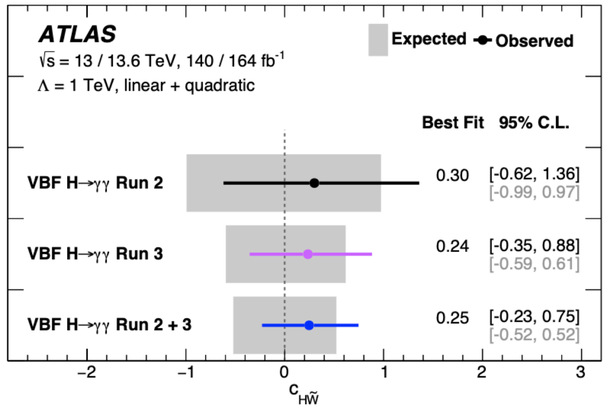
- For the first time, simultaneous constraints on the three CP-violating coefficients
- Over 40% improvement on individual limits for $c_{H\tilde{W}}$
- Most stringent constraints to date, with minimum model dependence
- No significant evidence for CP violation.
- All constraints are compatible with the SM.

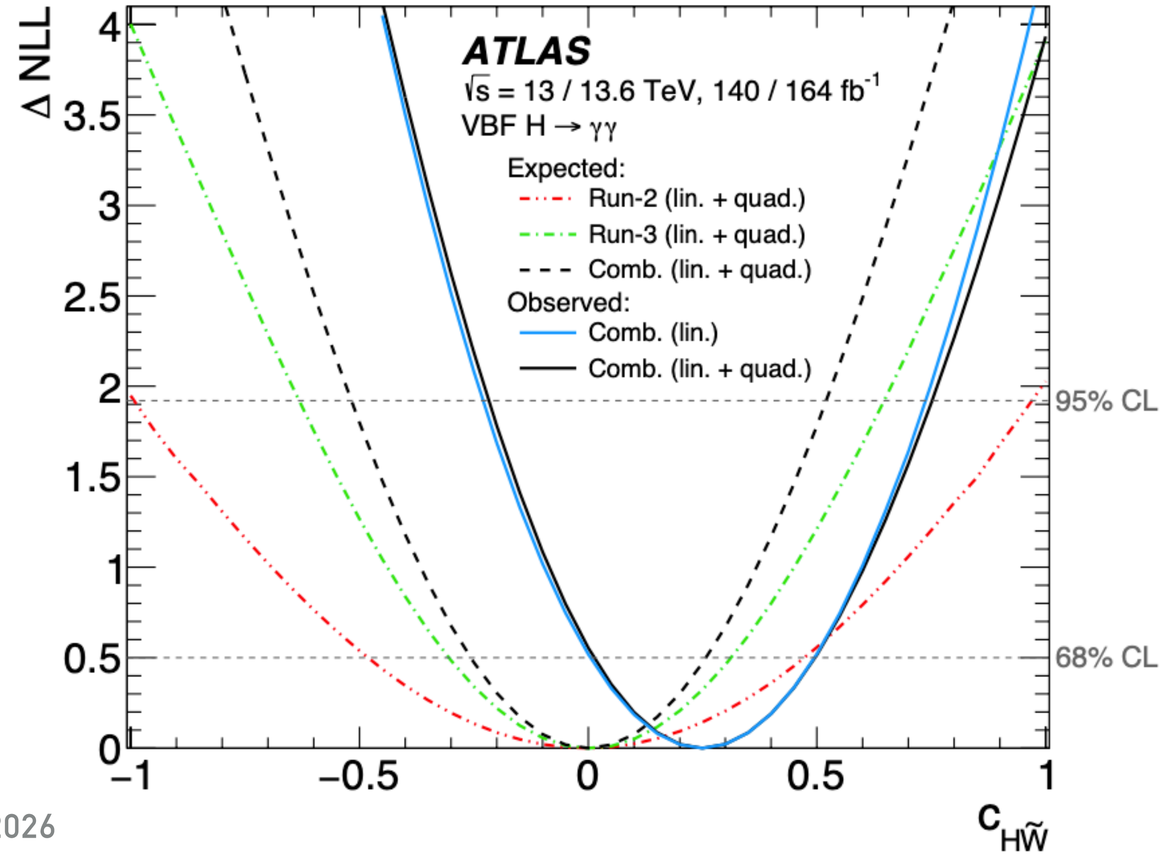


LATEST VBF H(YY) RESULT

arXiv:2603.20087

- Result using 164 fb^{-1} of data, collected in 2022-24 at 13.6 TeV
  - Follow-up to the run 2 result (arXiv:2208.02338)
  - Previous result is included in combination that was just shown
  - Statistical combination with the existing result to maximise sensitivity
- Constraint set on CP-odd coupling in SMEFT. Also included is a probe of longitudinal and transverse HVV couplings through angular distributions.
- Total improvement in run 3 w.r.t. run 2 is 38%, of which 29% due to implementation of multi-class NN with VBF, ggF and yyjj background output nodes
- No significant deviation from SM





'GLOBAL' SMEFT

arXiv:2604.21670

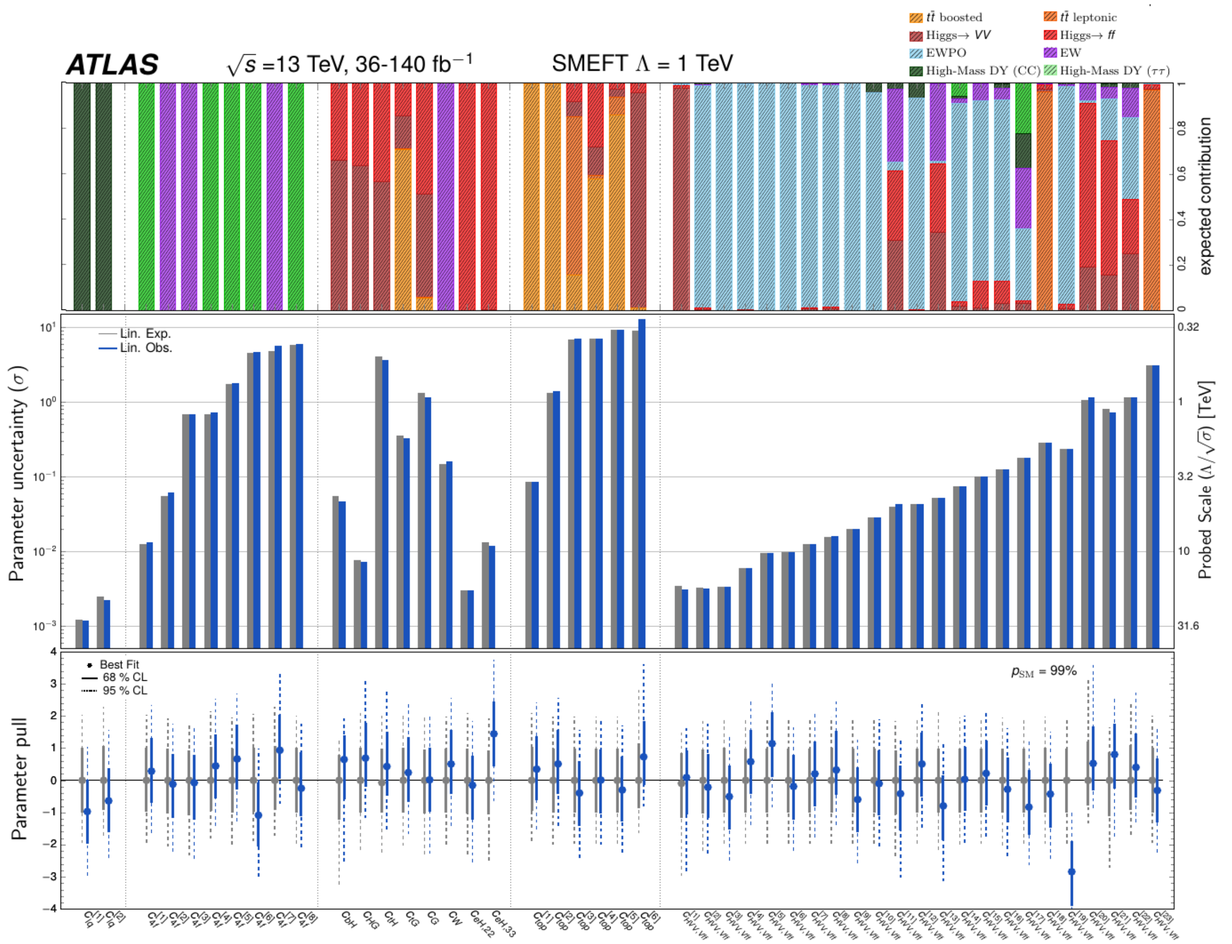
- Combination of measurements with Higgs, EW bosons and top, using up to 140 fb^{-1} of data, collected in 2015-18 at 13 TeV.
- Using the EFT framework to connect the Higgs sector to the other measurements in ATLAS (and some beyond)
  - The Higgs combination uses arXiv:2402.05742 the predecessor to the result shown today
- The total number of operator coefficients that can be constrained individually using the included measurements is 86.
- As discussed before, this can be reduced by focussing on the experimentally accessible directions.

Process	Dataset [fb^{-1}]	SMEFT sensitivity
Higgs boson measurements [10–19]		
$pp \to H \to \gamma\gamma,\ ZZ^* \to 4\ell,\ WW^* \to \ell\nu\ell\nu$	140	Higgs boson operators
$pp \to H \to Z\gamma,\ \mu^+\mu^-$	140	Higgs boson operators
$pp \to H \to b\bar{b},\ \tau^+\tau^-$	126–140	Higgs boson operators
Electroweak measurements [22–24]		
$pp \to W^+W^- \to e^\pm\nu\,\mu^\mp\nu$	36	Four-fermion operators and triple gauge couplings
$pp \to W^\pm Z \to \ell^\pm\nu\,\ell^+\ell^-$	36	Four-fermion operators and triple gauge couplings
$pp \to Zjj \to \ell^+\ell^- jj$	140	Four-fermion operators and triple gauge couplings
HMDY measurements [25, 26]		
$pp \to Z/\gamma^* \to \tau^+\tau^-$	140	Four-fermion operators involving leptons
$pp \to W^\pm \to \ell^\pm\nu$	140	Four-fermion operators involving leptons
Top-quark measurements [27, 28]		
$pp \to t\bar{t} \to Wb\,Wb \to e^\pm\mu^\mp\nu\nu bb$	140	Four-fermion (heavy-flavour) operators
$pp \to t\bar{t} \to Wb\,Wb \to qq'b\,\ell\nu b$	140	Four-fermion (heavy-flavour) operators
Di-Higgs measurements [20, 21]		
$pp \to HH \to b\bar{b}\gamma\gamma,\ b\bar{b}\tau^+\tau^-$	140	Trilinear Higgs boson self-coupling
Electroweak precision observables [29–33]		
LEP, SLD, ATLAS EWPO	–	Weak boson–fermion couplings

'GLOBAL' SMEFT: RESULTS

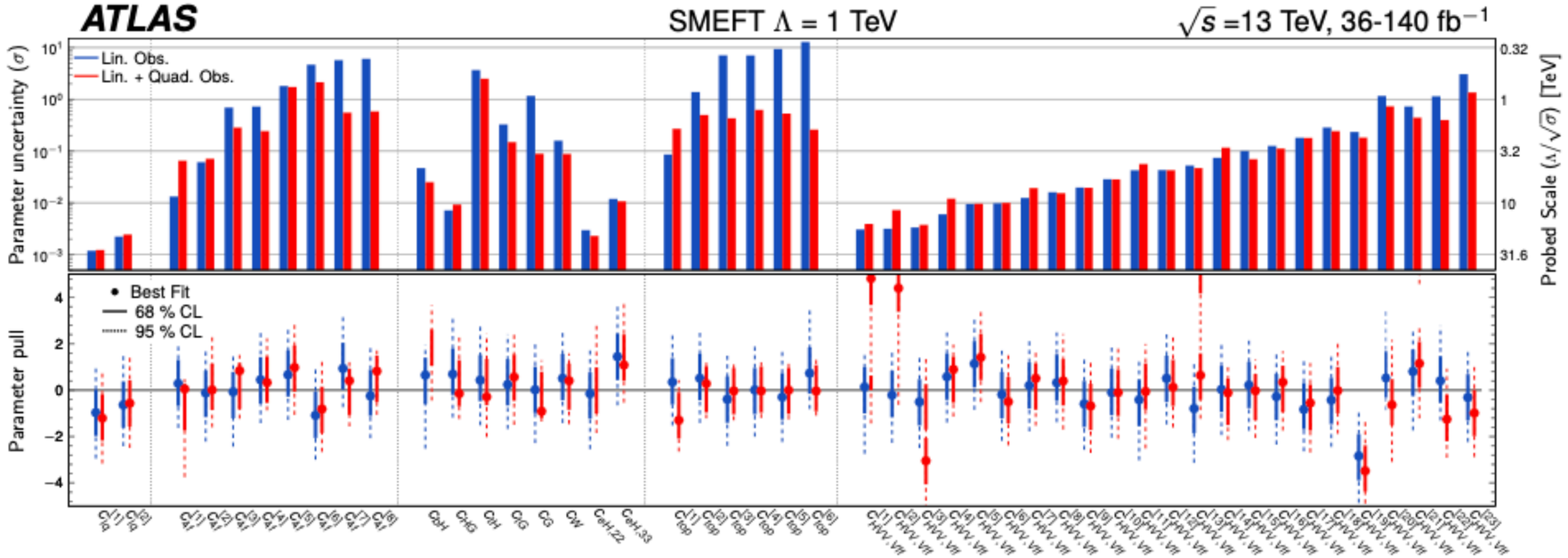
arXiv:2604.21670

- A total of 48 parameters, including individual Wilson coefficients in the Warsaw basis and linear combinations of Wilson coefficients, are constrained simultaneously.
- By matching a relevant subset of the results to their parameters, constraints are also obtained for two-Higgs-doublet models and heavy-vector-boson models.
- Shown here for the linear model, next slide for the comparison with linear+quadratic
- The pull for $c^{[19]}_{HVV,Vff}$ is dominated by the known $A^{0,b}_{FB}$ result from LEP



'GLOBAL' SMEFT: RESULTS

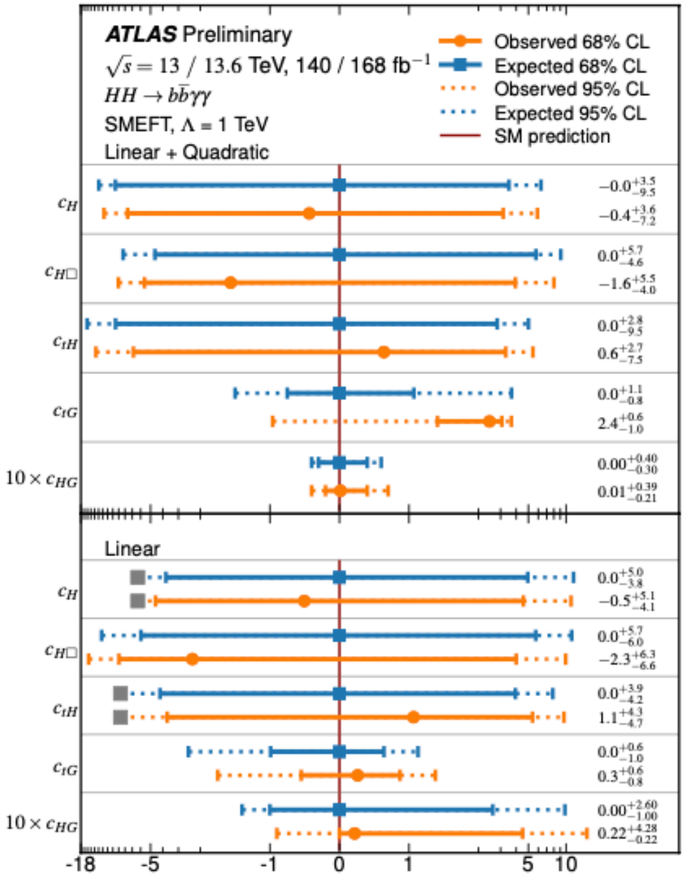
arXiv:2604.21670

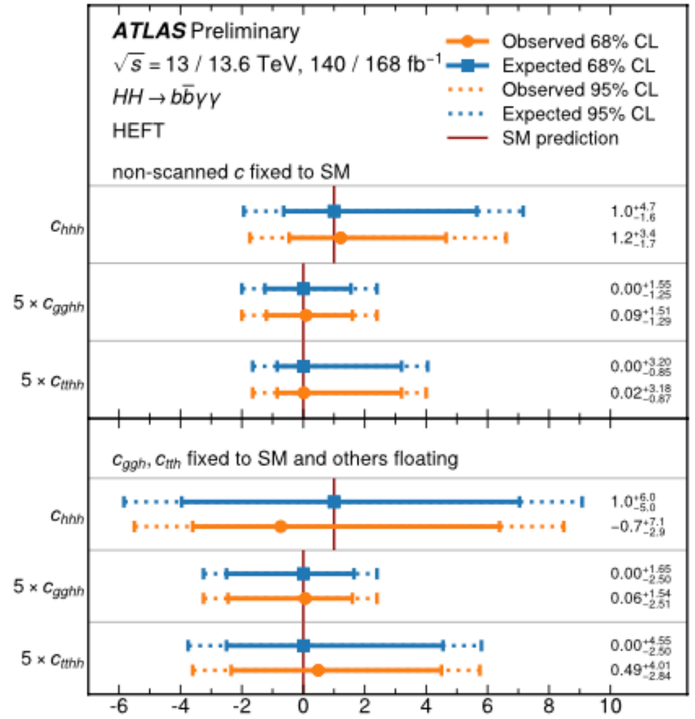


- This combined fit provides the most comprehensive effective field theory interpretation of experimental data by the ATLAS Collaboration to date.
- No significant deviations from the Standard Model are observed.

LATEST DI-HIGGS (BBYY) RESULTS

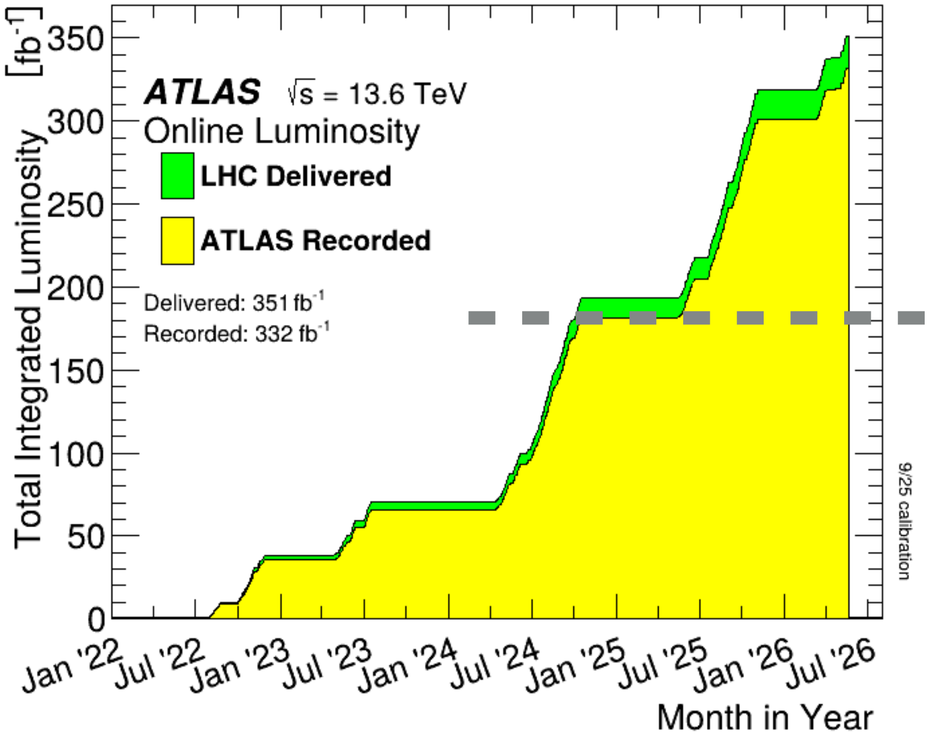
- Search for Higgs boson pair production in the $b\bar{b}\gamma\gamma$ final state
- Follow-up to the analysis using 140 fb^{-1} at 13 TeV. (arXiv:2310.12301)
  - This previous result is also included in both the Higgs and Global combinations
- Reanalyse the existing result and add 168 fb^{-1} of data collected in 2022-24 at 13.6 TeV
- First result to also consider EFT effects in VBF HH
- Interpreted in both SMEFT and HEFT formalisms
- Wilson-coefficient constraints improve by 30%-50% (24%-45% for HEFT) relative to the previous publication
- All observations are consistent with the predictions of the SM.





CONCLUSION

- Showed three combinations using up to 140 fb^{-1} of data collected in 2015-18
  - Shows increasingly strong EFT constraints!
- Three new Run-3 results, using up to 168 fb^{-1} from the 2022–24 dataset, already demonstrate significant improvements
- The combinations will continue to improve as more Run-2/Run-3 inputs are updated
- An additional ~150 fb^{-1} of data from 2025 and 2026 will push sensitivity even higher
- Stay tuned!



More to come from 2025-26 dataset

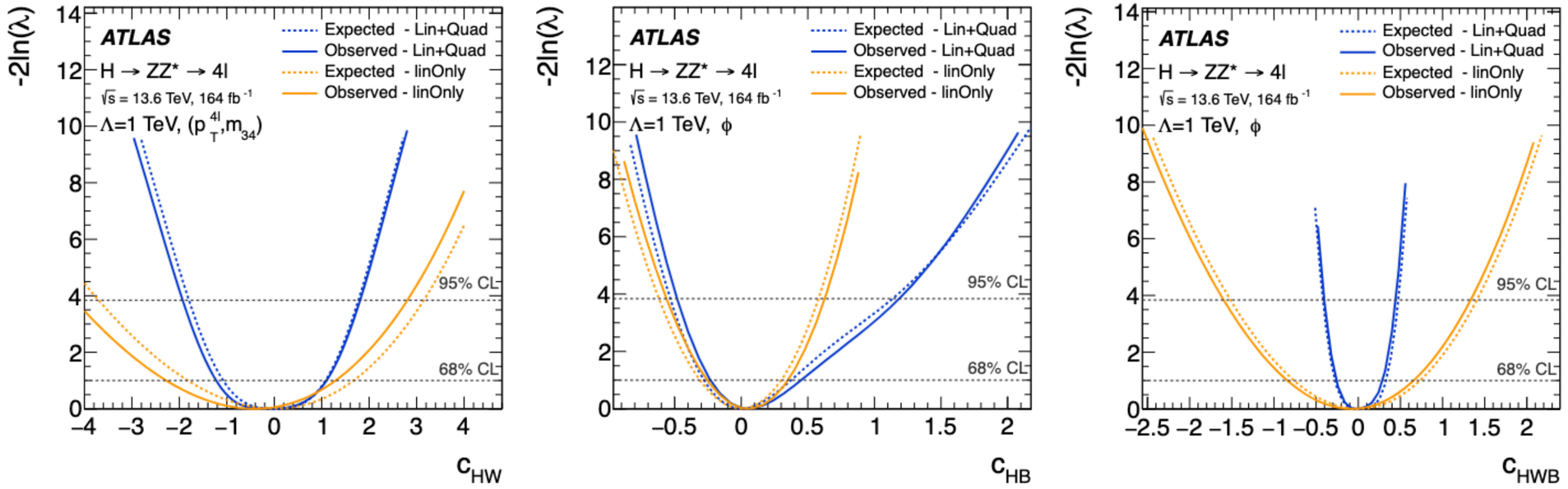
First results with 2022-24 dataset published!

BACKUP

LATEST H4L 1D RESULTS

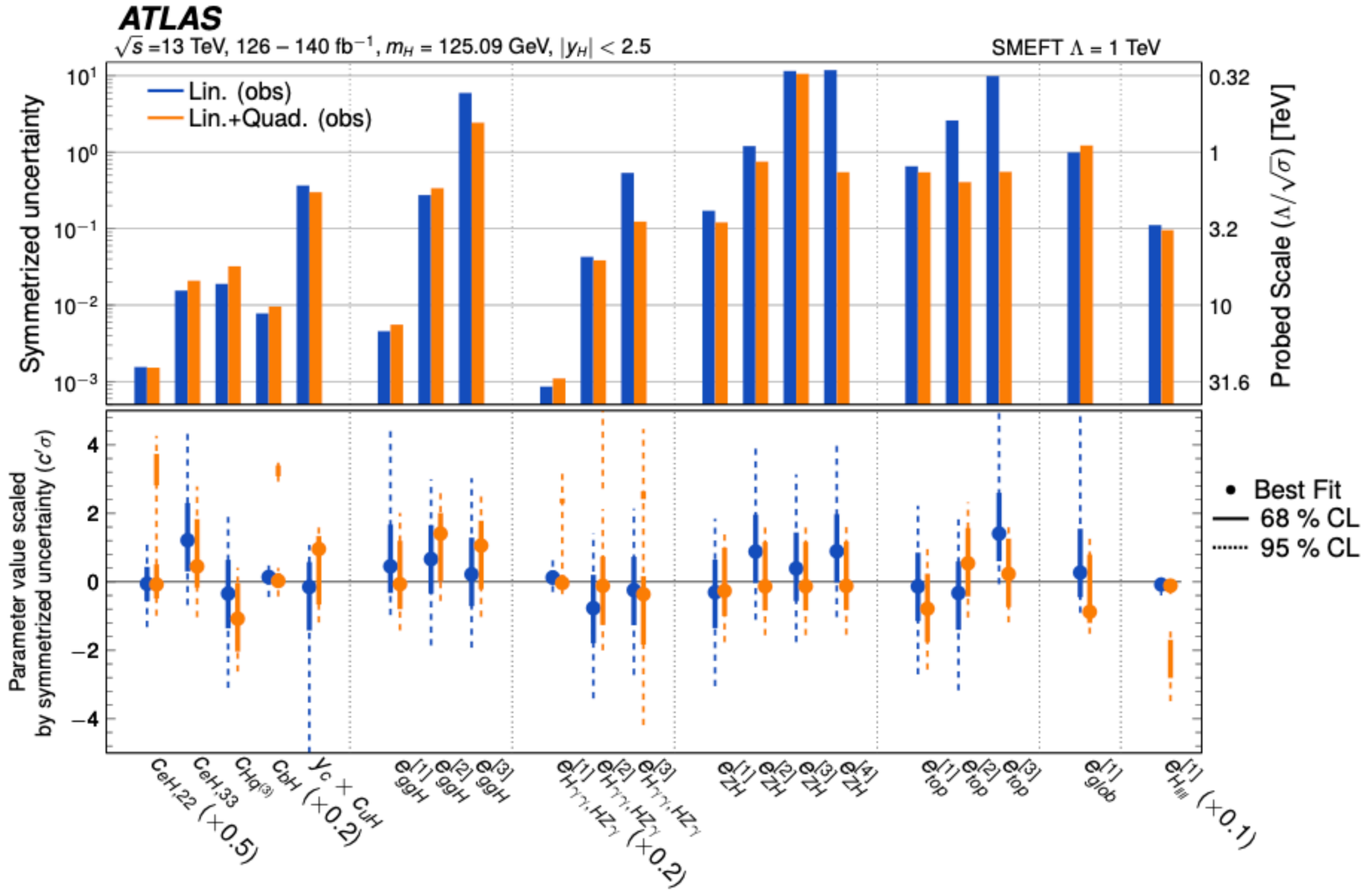
arXiv:2605.19016

- 1D used for limits, 2D to illustrate correlations



HIGGS COMBINATION: LINEAR + QUADRATIC

arXiv:2608.07332



LATEST DI-HIGGS (BBYY) RESULTS: VBF HH DIAGRAMS

ATL-PHYS-PUB-2025-034

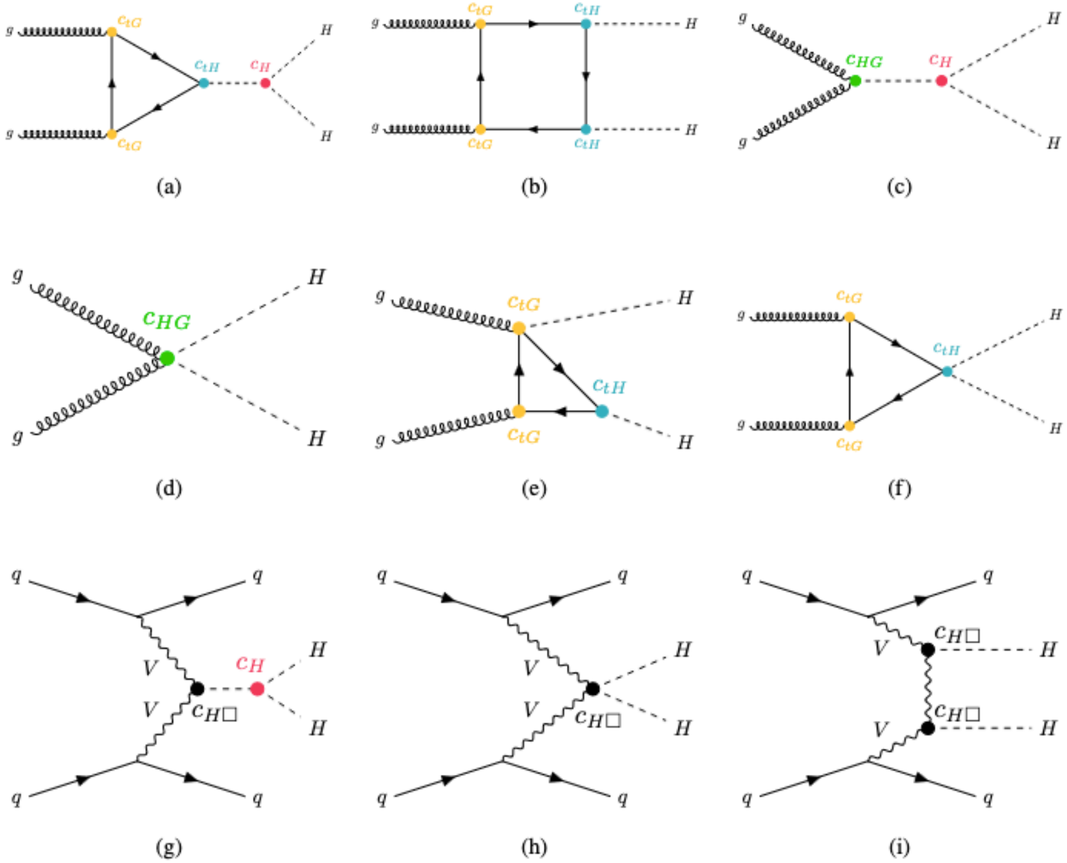


Figure 1: Leading order Feynman diagrams for ggF (a-f) and VBF (g-i) HH production, indicating the vertices that are affected by SMEFT Wilson coefficients c_H, c_{HG}, c_{tH}, c_{tG}, and $c_{H\Box}$. The Wilson coefficient $c_{H\Box}$ modifies every Higgs interaction vertex and is only illustrated for vertices unaffected by other Wilson coefficients.

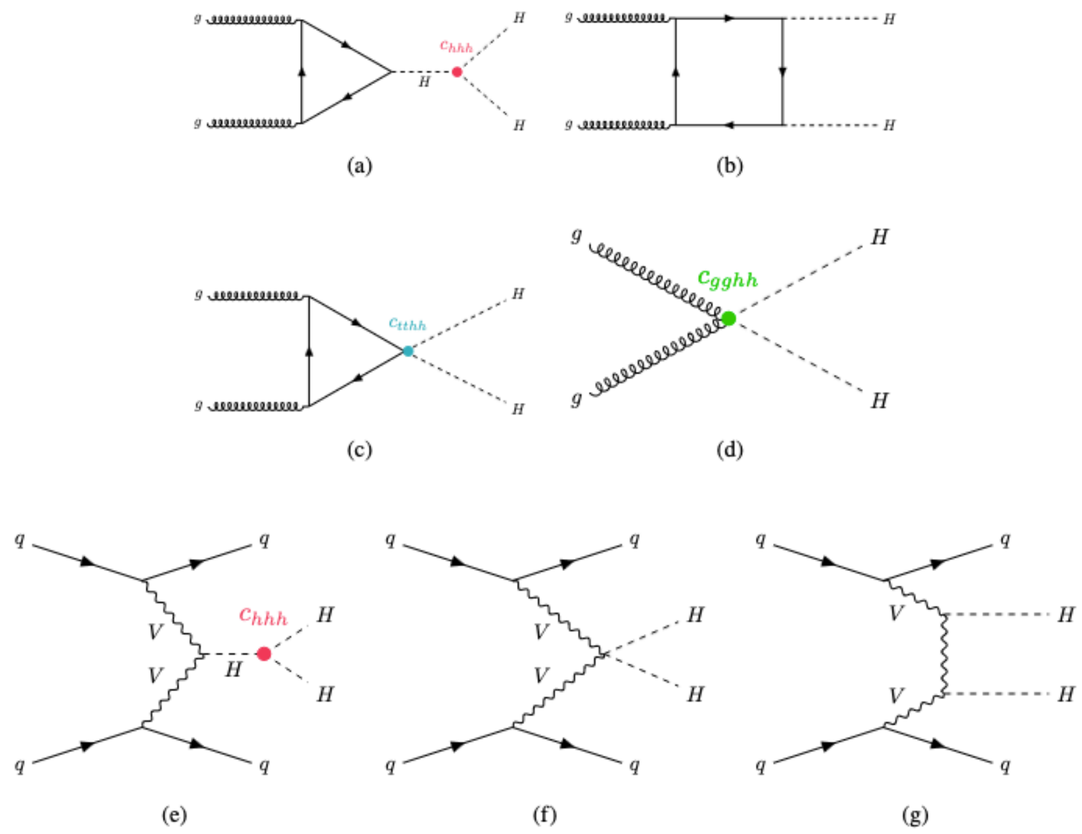


Figure 2: Leading order Feynman diagrams for ggF (a-d) and VBF (e-g) HH production indicating the vertices that are affected by HEFT Wilson coefficients c_{hhh}, c_{tthh}, and c_{gghh}. Diagrams f and g are not modified by the HEFT operators considered in this analysis.