EFT measurements in ATLAS

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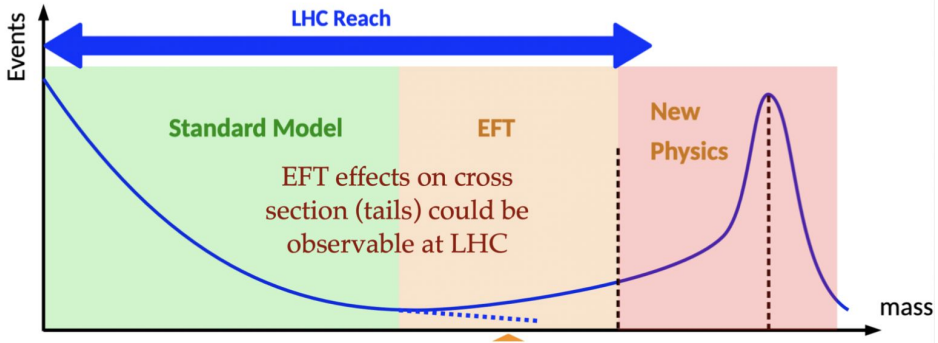
Introduction

Direct searches

- Look for a bump in a spectrum



Indirect searches

- Look for a deviation from SM
- Potential effect of new heavy particles parametrised within EFT framework
  - Fairly model independent

(SM)EFT

Extend SM Lagrangian by introducing terms of higher dimension

Wilson coefficients

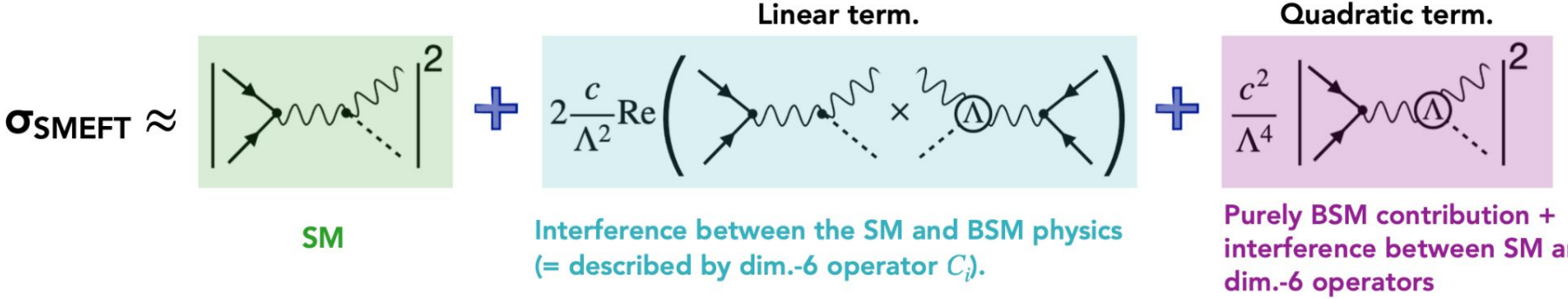
$$\mathcal{L}_{\text{SMEFT}} = \mathcal{L}_{\text{SM}} + \sum_i \frac{c_i^{(5)}}{\Lambda} Q_i^{(5)} + \sum_i \frac{c_i^{(6)}}{\Lambda^2} Q_i^{(6)} + \sum_i \frac{c_i^{(7)}}{\Lambda^3} Q_i^{(7)} + \sum_i \frac{c_i^{(8)}}{\Lambda^4} Q_i^{(8)} + \cdots$$

Scale of new physics (usually set to 1TeV)

- ➔ Terms of d=5,7 violate lepton/baryon number conservation
  - ◆ Usually not considered at colliders
- ➔ Leading order contribution from d=6
  - ◆ Incomplete description of d=8 terms

(SM)EFT

Goal: use LHC data to place constraints on various Wilson coefficients

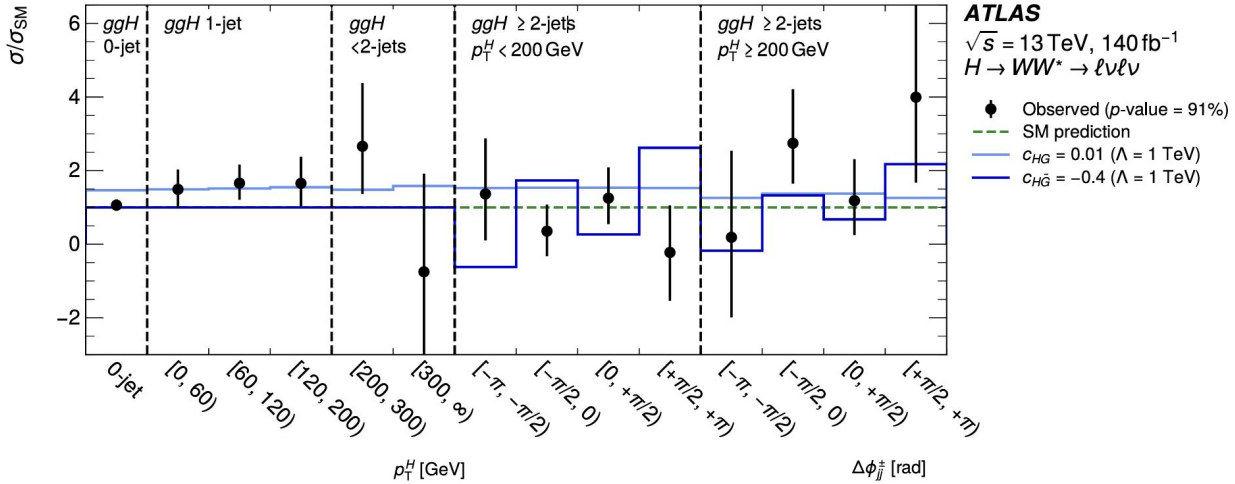


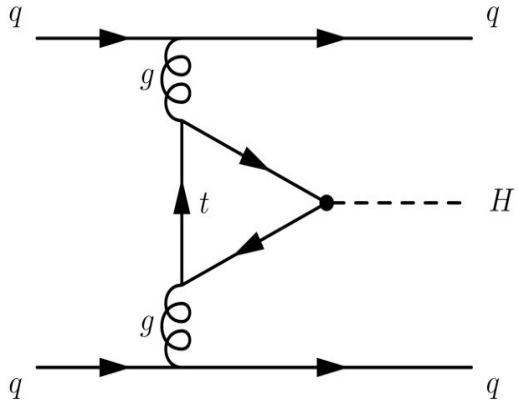
$$\sigma_{\mathrm{SMEFT}} = \sigma_{\mathrm{SM}} + \sigma_{\mathrm{int}} + \sigma_{\mathrm{BSM}}$$

- Design analyses to be sensitive to (some) wilson coefficients c_i
- Reinterpret measurements to place constraints on c_i (usually cross-sections)

HVV interaction

- ggF and VBF production and H→WW* and H→$\tau\tau$ decay
- CP-odd + CP-even ➙ different effects on distributions such as $\Delta\varphi_{jj}$
- Dominated by d=6 wilson coefficients
- cross-section measurements as input

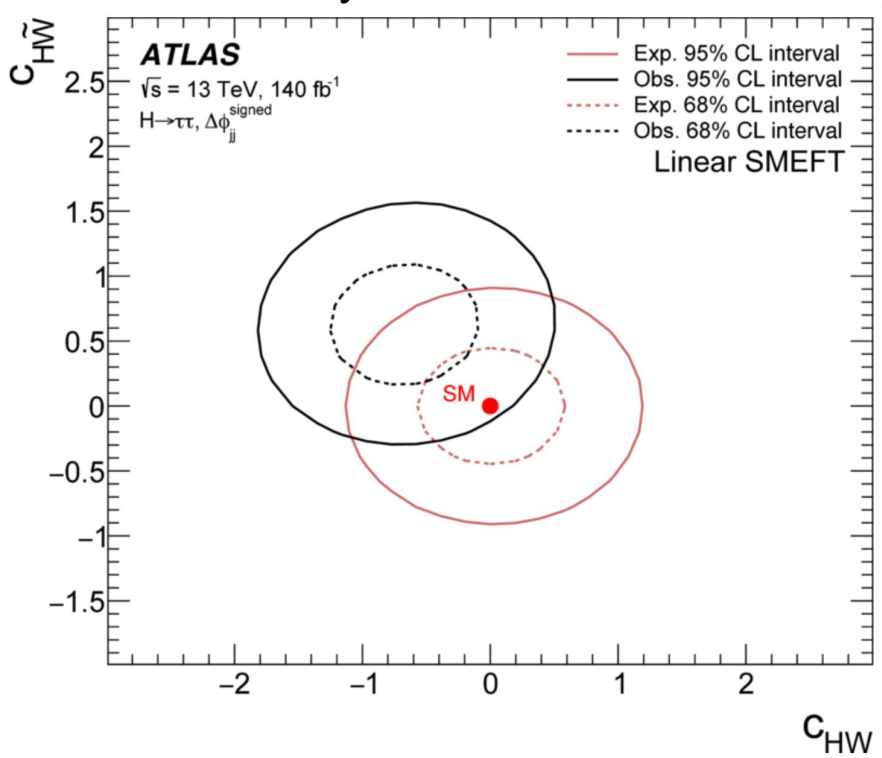




JHEP 03 (2025) 010 arXiv:2506.19395 arXiv:2504.07686

HVV interaction

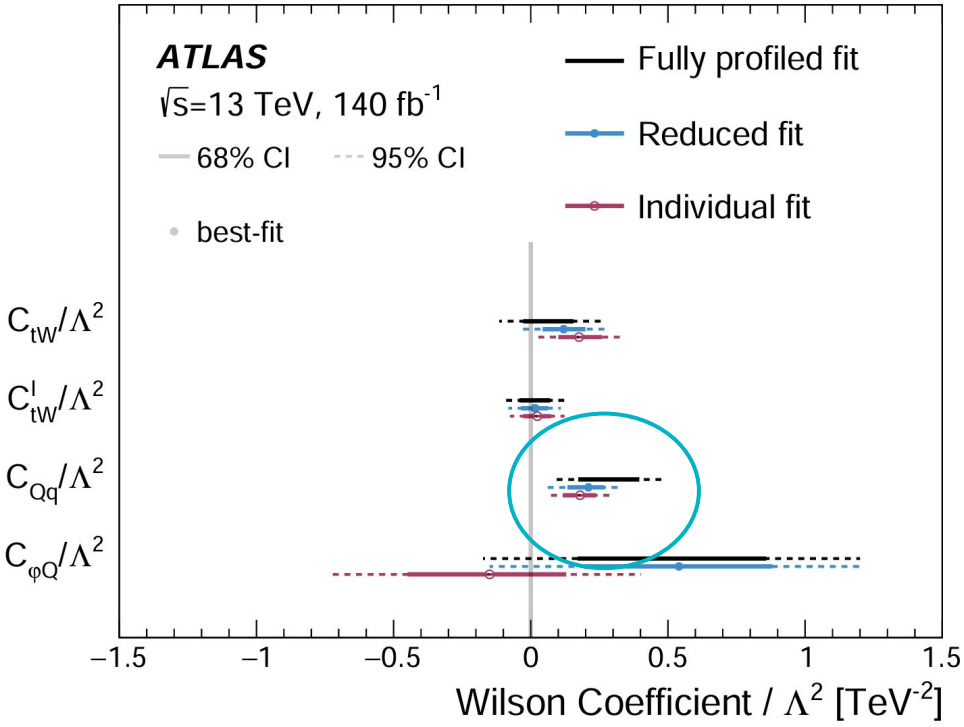
- ggF and VBF production and H→WW* and H→$\tau\tau$ decay
- CP-odd + CP-even
- Dominated by d=6 wilson coefficients
- STXS measurements as input
- All results compatible with SM



arXiv:2510.23372,
arXiv:2601.04938

Top measurements

- Study of 4 angles that define t→bW decay
  - Dominated by systematic uncertainties
- Study of production using unfolded $p_T(tt)$
  - No significant deviation in same parameter



arXiv:2604.21670 arXiv:2504.02958

Global fits

Combining (di-)Higgs, EW, top, HMDY and EW from previous experiments

Process	Dataset [fb^{-1}]	SMEFT sensitivity
Higgs boson measurements		
$pp \to H \to \gamma\gamma,\ ZZ^* \to 4\ell,\ WW^* \to \ell\nu\ell\nu$	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		
$pp \to W^+W^- \to e^\pm\nu\,\mu^\mp\nu$	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		
$pp \to Z/\gamma^* \to \tau^+\tau^-$	140	four-fermion operators involving leptons
$pp \to W^\pm \to \ell^\pm\nu$	140	four-fermion operators involving leptons
Top-quark measurements		
$pp \to t\bar{t} \to WbWb \to e^\pm\mu^\mp\nu\nu bb$	140	four-fermion (heavy-flavour) operators
$pp \to t\bar{t} \to WbWb \to qq'b\,\ell\nu b$	140	four-fermion (heavy-flavour) operators
Di-Higgs measurements		
$pp \to HH \to b\bar{b}\gamma\gamma,\ b\bar{b}\tau^+\tau^-$	140	trilinear Higgs boson self-coupling
Electroweak precision observables		
LEP, SLD, ATLAS EWPO	–	Weak boson–fermion couplings

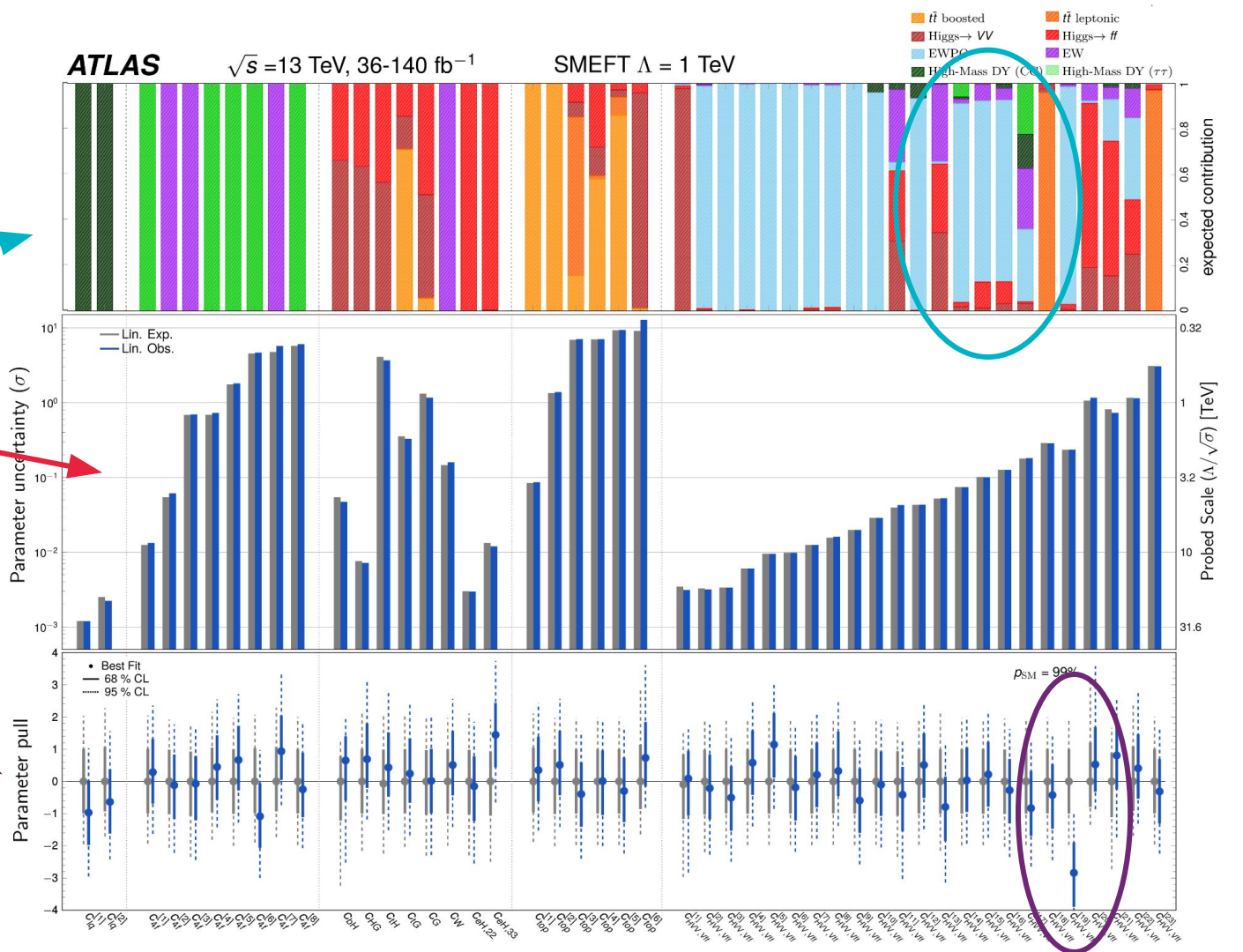
- CP-conserving operators only
- Resolve degeneracies
- Generally, BSM effects only considered for signal processes
- **One-at-a-time fits (64 operators)**
- **Multi-coefficient constraints (PCA, 42 EVs)**
- Results with simplified model using covariance matrix

Global fits

Complementary analyses

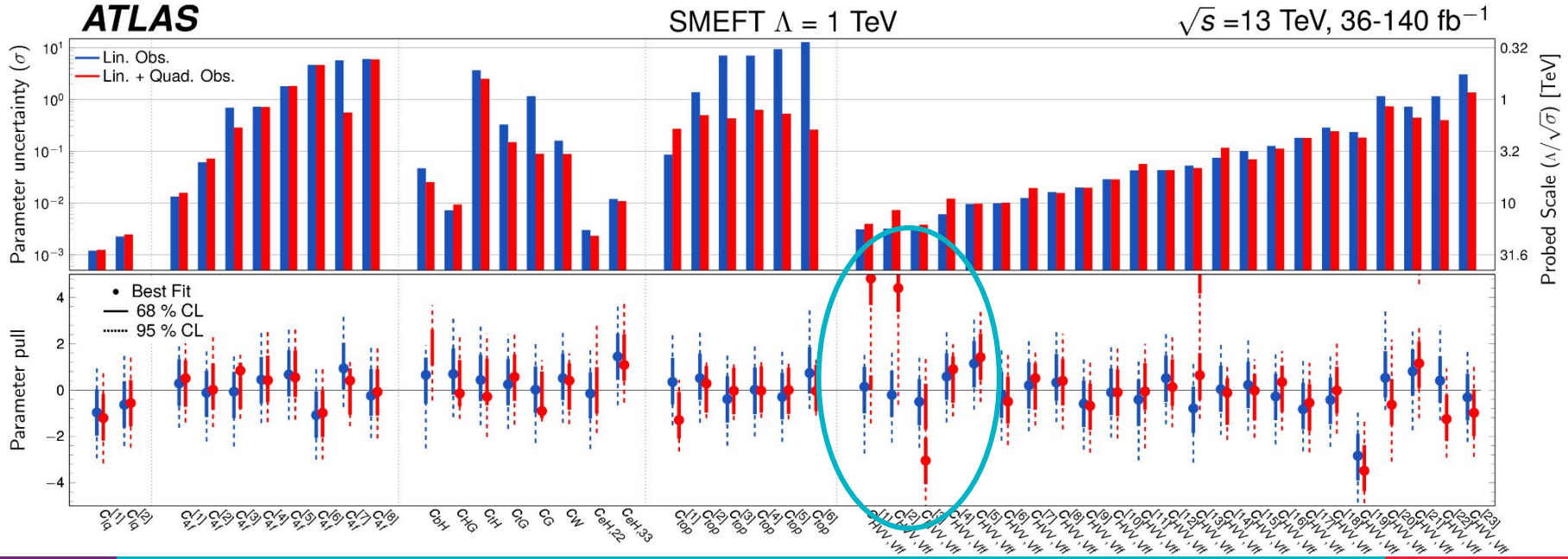
Probed scales

Good complementa



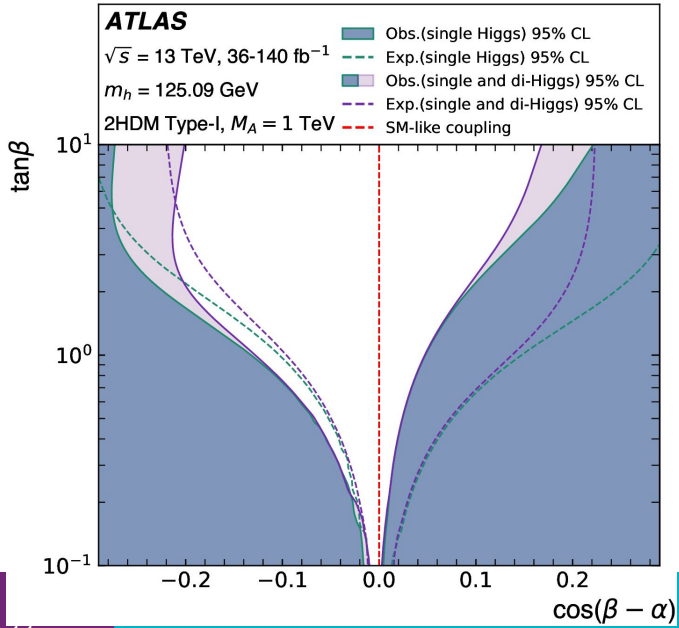
Global fits

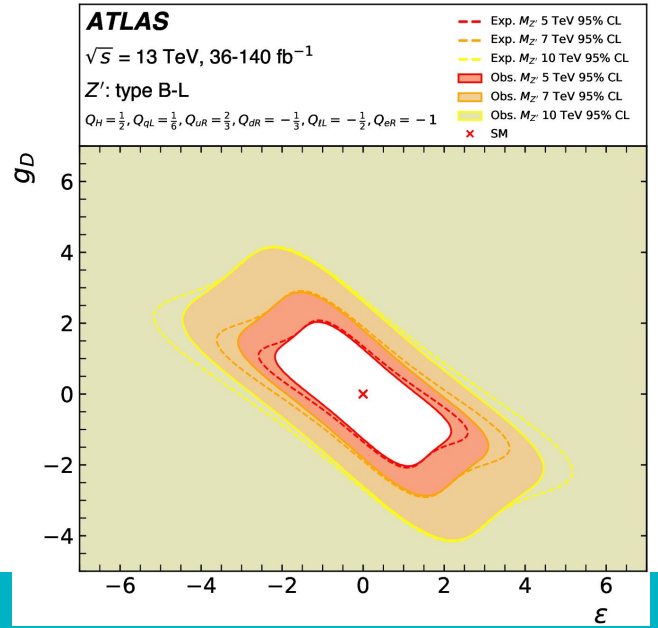
Comparison of linear vs linear+quadratic



Global fits: UV matching

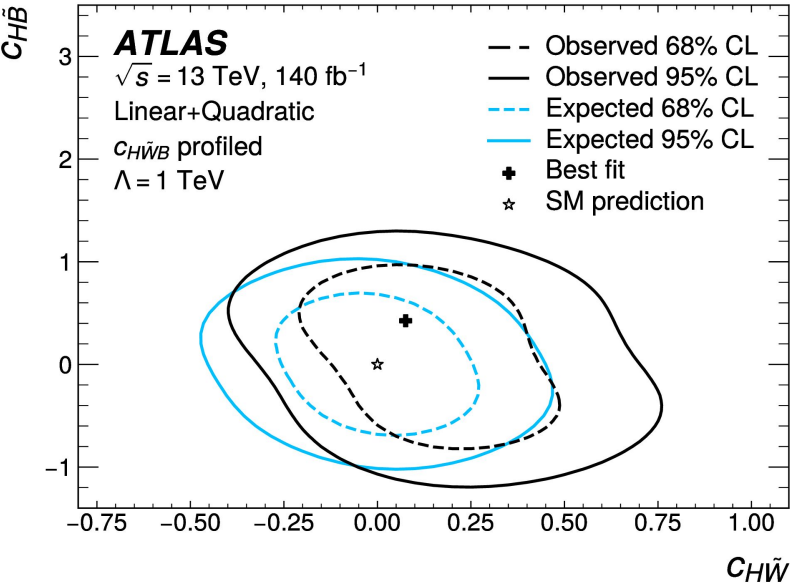
Matching from EFT to 2HDM and Z' models

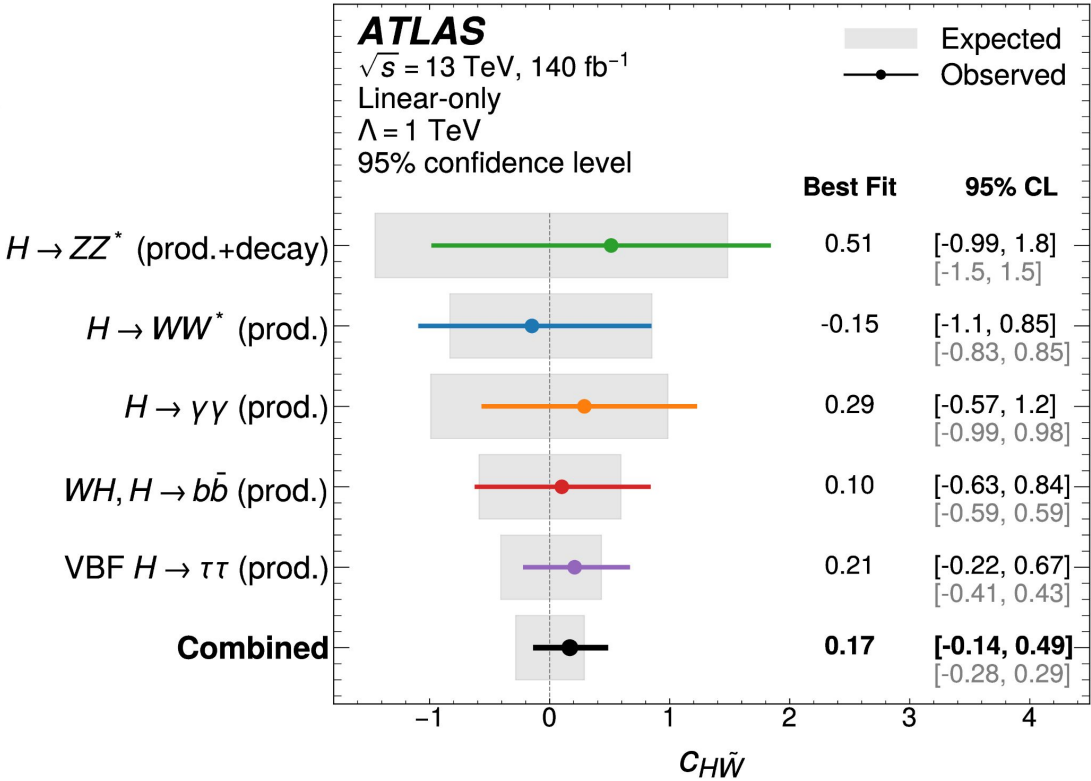




CP combination

Improved limits on $c_{H\tilde{W}}$, $c_{H\tilde{B}}$, and $c_{H\tilde{W}B}$





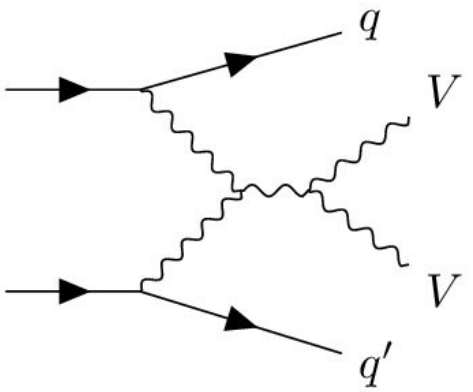
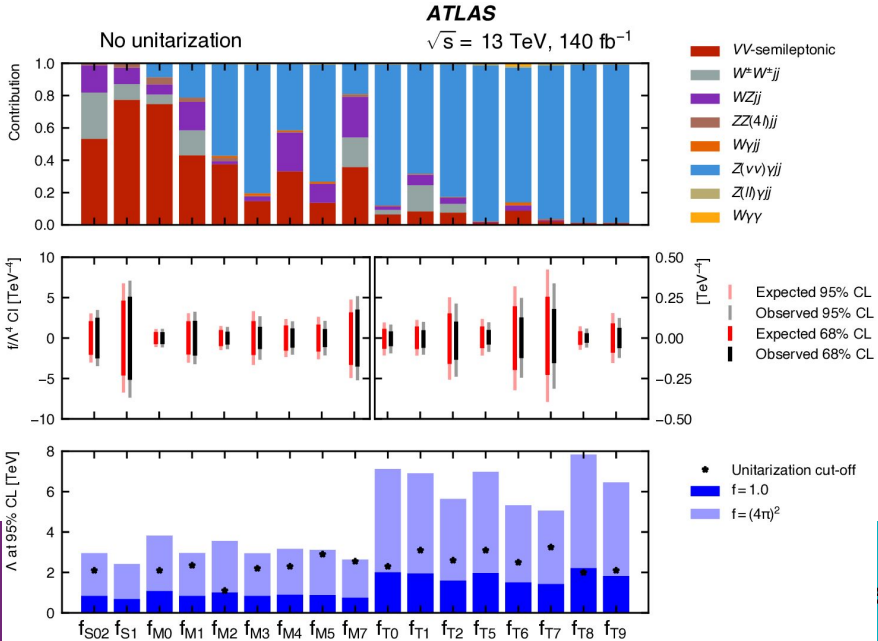
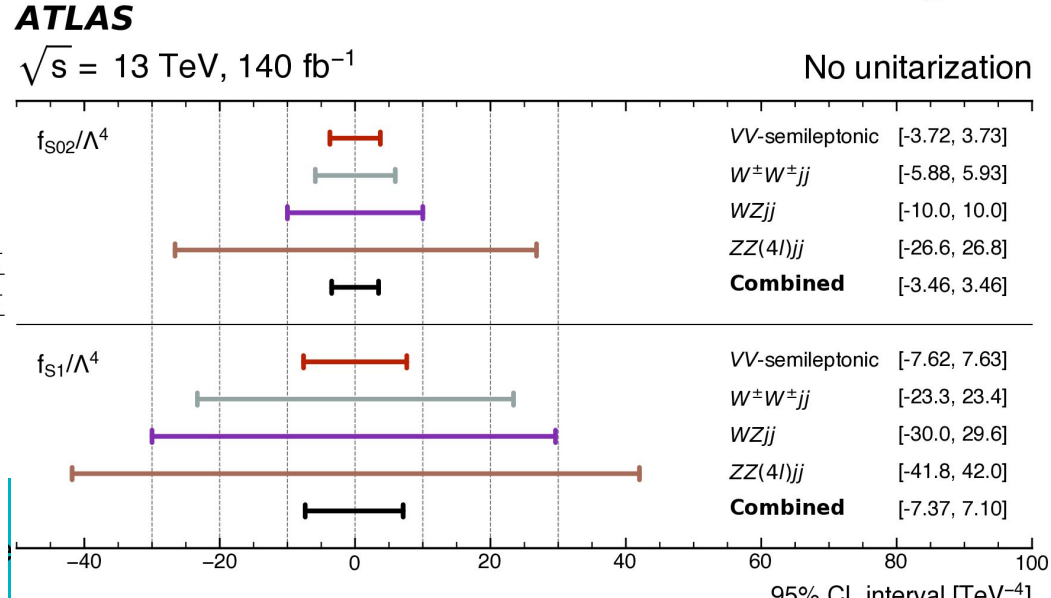
Conclusions

- Many new EFT results using Run 2 data + first results with Run 3 data
- EFT fits benefit from **combinations** (esp. to resolve flat directions)
  - Important that input analyses be orthogonal → not always the case!
  - Addressed by cutting away overlap in phase-space/events, bootstrapping
- **Interesting/new techniques** to improve measurements
- Overall, results tend to be limited by available statistics

  → Run 3 data very useful

Back-up

arXiv:2603.18630

Quartic gauge boson couplings

- Dimension-8 operators in the Eboli model
- Both with and without unitarity constraints applied