



ATL-PHYS-PUB-2022-037

A common Lagrangian

SMEFT is a low-energy description of a fundamental theory at energy scale $\Lambda \gg \langle v \rangle, E$
Lagrangian consists of higher dimensional operators $\{\mathcal{O}_i^d (d > 4)\}$ & captures all
allowed local contact interactions with known symmetries

$$\mathcal{L}_{\text{SMEFT}} = \mathcal{L}_{\text{SM}} + \sum_i \frac{c_i^{(5)}}{\Lambda} \mathcal{O}_i^{(5)} + \sum_i \frac{c_i^{(6)}}{\Lambda^2} \mathcal{O}_i^{(6)} + \dots \text{ terms suppressed by } 1/\Lambda^{d>2}$$

Weinberg operator - violates B, L (not relevant for this analysis) focus of this analysis Wilson coefficients : Parameters of Interest

Operators defined in Warsaw basis (2499 operators) $\xrightarrow{\text{flavour symmetry}}$ (182 operators)

topU3I flavour symmetry : dedicated operators affecting top & bottom quarks

[Allows to probe indirect signs of new physics physics in a model-agnostic manner](#)

Operator impact on measurements

SMEFT parameterisation of kinematic bins given as polynomial in Wilson coefficients:

$$\sigma = |\mathcal{A}_{\text{SMEFT}}|^2$$

$$= |\mathcal{A}_{\text{SM}}|^2 + \sum_i \frac{c_i^{(6)}}{\Lambda^2} 2\text{Re}(\mathcal{A}_i^{(6)} \mathcal{A}_{\text{SM}}^*) + \sum_i \frac{(c_i^{(6)})^2}{\Lambda^4} |\mathcal{A}_i^{(6)}|^2 + \sum_{i < j} \frac{c_i^{(6)} c_j^{(6)}}{\Lambda^4} 2\text{Re}(\mathcal{A}_i^{(6)} \mathcal{A}_j^{(6)*}) + \text{missing interference}$$

Matrix element relation

+ ... terms suppressed by $1/\Lambda^{d>4}$

Linear Quadratic

Parameterisation derived from both MC simulations and analytical predictions :

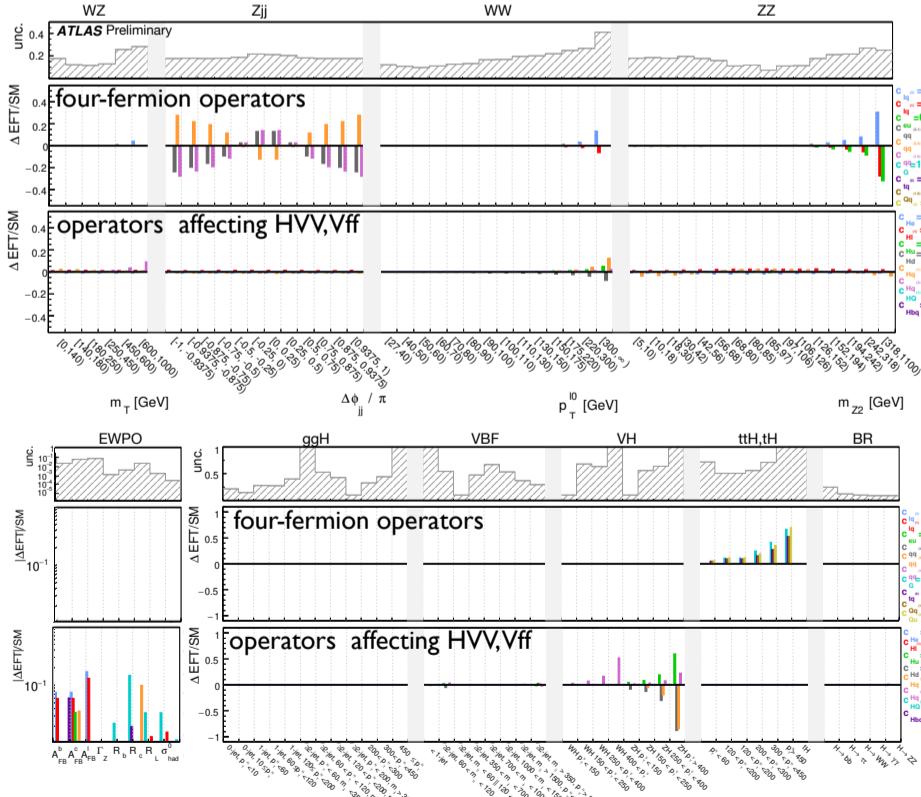
Predictions for tree-level EFT insertion with SMEFTsim 3.0

SMEFTatNLO to resolve important loop contribution ($gg \rightarrow ZH, gg \rightarrow H, H \rightarrow gg$)

Analytical predictions for $H \rightarrow \gamma\gamma$ and EWPO observables

62 operators relevant for processes considered in this analysis

Kinematic impact of some of the SMEFT operators shown below,



Many operators affect measurements with similar impact, cannot distinguish individually

→ Identify sensitive directions within operators group using
principle component analysis of Fisher information matrix

Inputs

Electroweak precision observables (EWPO) from Z-resonance data from LEP & SLC

Kinematic information of Higgs production
from 5 decay channels, measured in the
simplified cross-section framework

Unfolded differential measurements
of di-boson (WW,WZ,ZZ)
& Z-boson (Z+2jets)

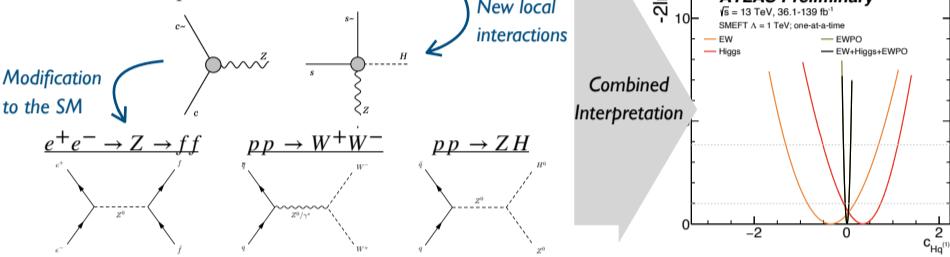
Remove categories with overlapping event selections across different analyses
Common treatment for systematics sources of uncertainties

ATLAS Run-2 measurements

One model to interpret them all

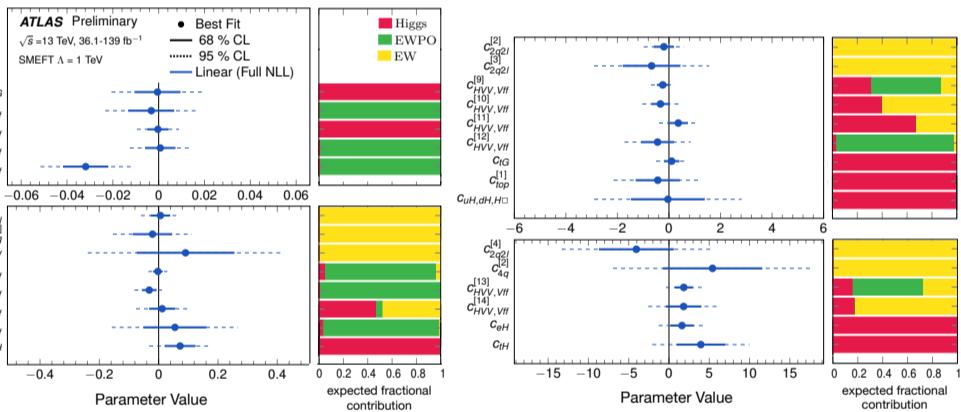
SMEFT framework allows to probe deviations across different measurements

For instance, $Q_{Hq}^{(1)} = (H^\dagger i \overleftrightarrow{D}_\mu^i H)(\bar{q}_p \gamma^\mu q_r)$



Constraint on SMEFT parameters

Sensitive to 28 parameters in total !



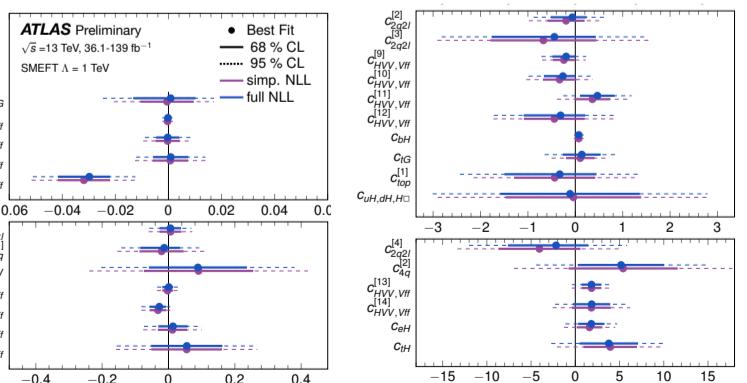
$$c \sim O(0.01 - 0.1) \leftarrow \text{Limits on SMEFT parameters} \rightarrow c \sim O(1 - 10)$$

$$\Lambda \sim O(3 - 10 \text{ TeV}) \leftarrow \text{probe energy scales upto} \rightarrow \Lambda \sim O(0.3 - 1 \text{ TeV})$$

Simplified likelihood

Simplified likelihood allow to approx. well the full likelihood function for measurements

$$L(\mu) = \frac{1}{\sqrt{(2\pi)^n \det(C_\mu)}} \exp\left(-\frac{1}{2} \Delta\mu^\top C_\mu^{-1} \Delta\mu\right), \quad \Delta\mu = \mu - \hat{\mu}.$$



Light-weight manner to reproduce SMEFT constraints

First ATLAS global SMEFT fit, including eight EWPO → Grow into more global combination inc. top, Drell-Yan & many more