# Top and Higgs data interplay in the SMEFT framework

UCLouvain

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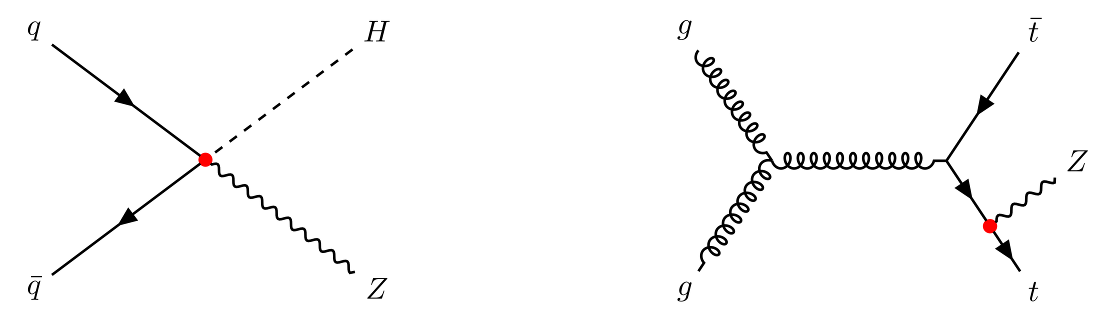
## Theoretical framework: SMEFT

$$\mathcal{L} = \mathcal{L}_{SM} + \sum_i \frac{1}{\Lambda}\mathcal{O}_i^5 + \sum_i \frac{1}{\Lambda^2}\mathcal{O}_i^6 + \ldots$$

The fundamental assumption at the foundation of SMEFT is that New Physics is heavier than the energies we can probe in experiments and therefore we can only see the **indirect effects** of it.
In this framework, the SM is extended with a tower of higher dimensional operators which induce **new interactions** among known particles, keeping a **model-independent** perspective.

SMEFT is **global**. The same operator affects multiple processes and sectors at the same time:

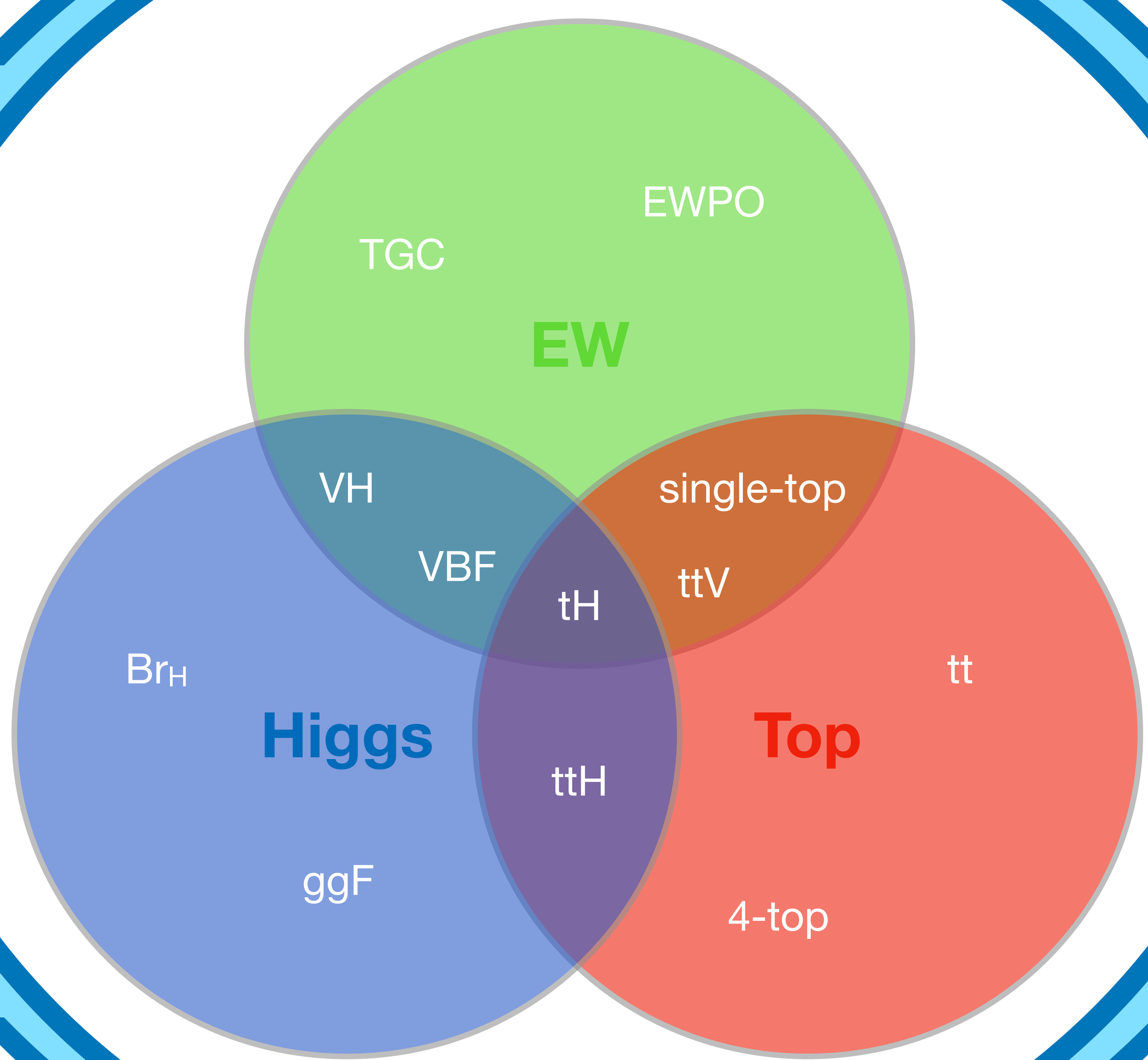



$$\mathcal{O}_{\varphi Q}^{(3)} = i(\phi^\dagger \overleftrightarrow{D}_\mu \tau_I \phi)(\bar{Q}\gamma^\mu \tau^I Q)$$

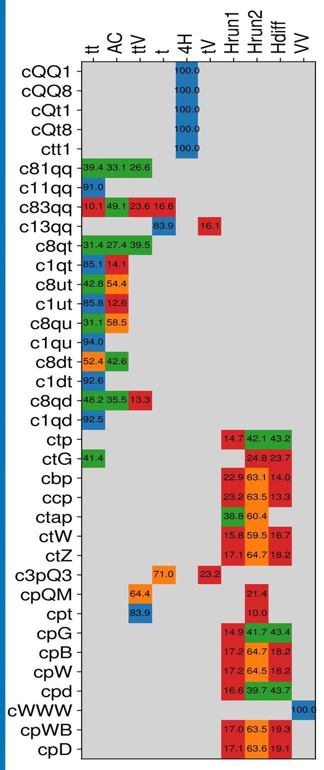
## Data: Higgs-top-EW combination

In order to break degeneracies in the SMEFT parameter space and increase our chances of finding evidence of New Physics, we need to combine several observables. We take advantage of the several measurements from LHC and LEP.

| Category | Processes | $n_{\rm dat}$ |
|---|---|---|
| Top quark production | $t\bar{t}$ (inclusive) | 94 |
| | $t\bar{t}Z$, $t\bar{t}W$ | 14 |
| | single top (inclusive) | 27 |
| | $tZ$, $tW$ | 9 |
| | $t\bar{t}t\bar{t}$, $t\bar{t}b\bar{b}$ | 6 |
| | **Total** | **150** |
| Higgs production and decay | Run I signal strengths | 22 |
| | Run II signal strengths | 40 |
| | Run II, differential distributions & STXS | 35 |
| | **Total** | **97** |
| Diboson production | LEP-2 | 40 |
| | LHC | 30 |
| | **Total** | **70** |
| Baseline dataset | **Total** | **317** |




## EFT sensitivity



**Fisher Information**

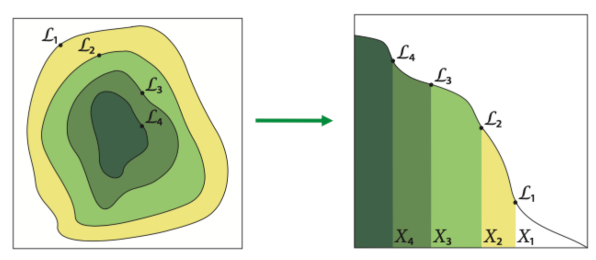
$$I_{ij} = \sum_{m=1}^{n_{\rm dat}} \frac{\sigma_{m,i}^{(\rm eft)}\sigma_{m,j}^{(\rm eft)}}{\delta^2_{{\rm exp},m}}$$

Provides information on the sensitivity of each dataset from the SMEFT operators.
The Fisher matrix can also be used to find the optimal directions in parameter space.

## Methodology

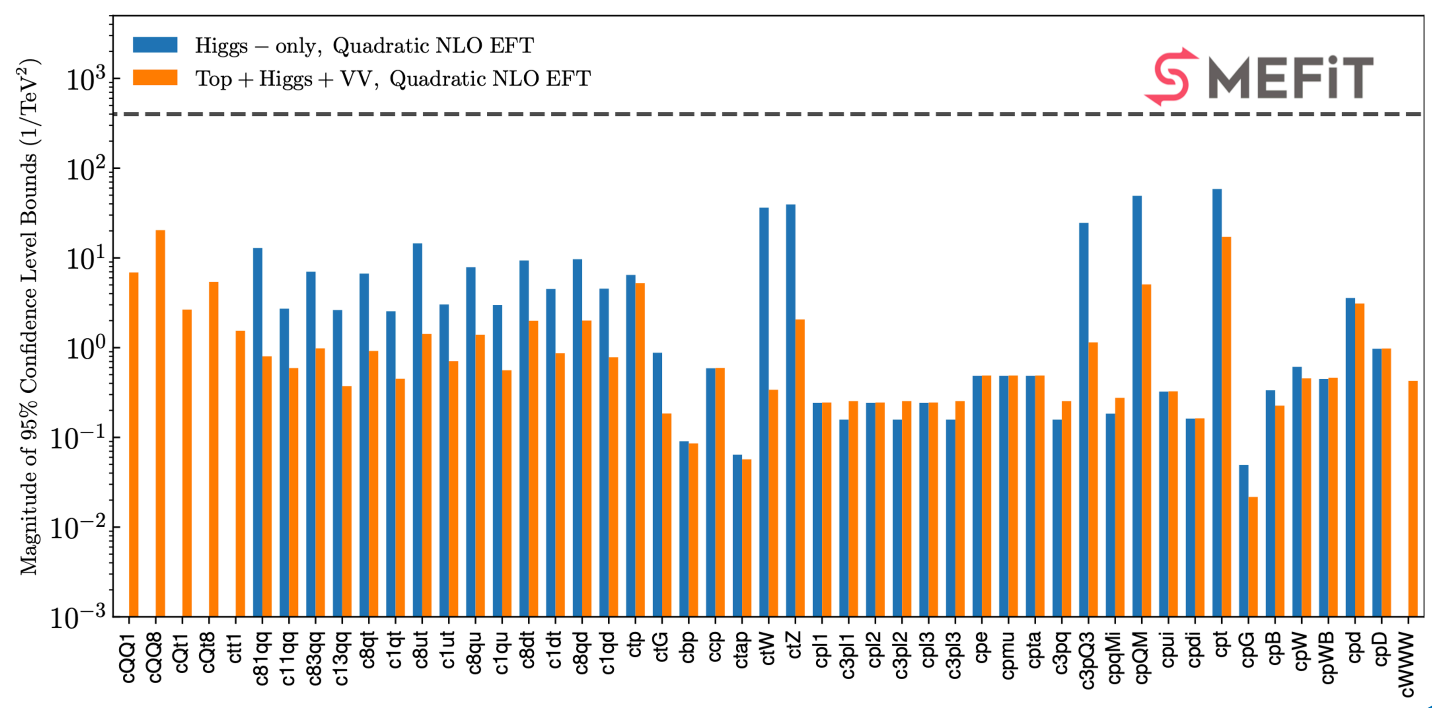
**Nested Sampling:** statistical mapping of the likelihood.

$$Z = \int d^N c \mathscr{L}(\text{data}\,|\,\vec{c})\,\pi(\vec{c}) = \int_0^1 dX \mathscr{L}(X)$$



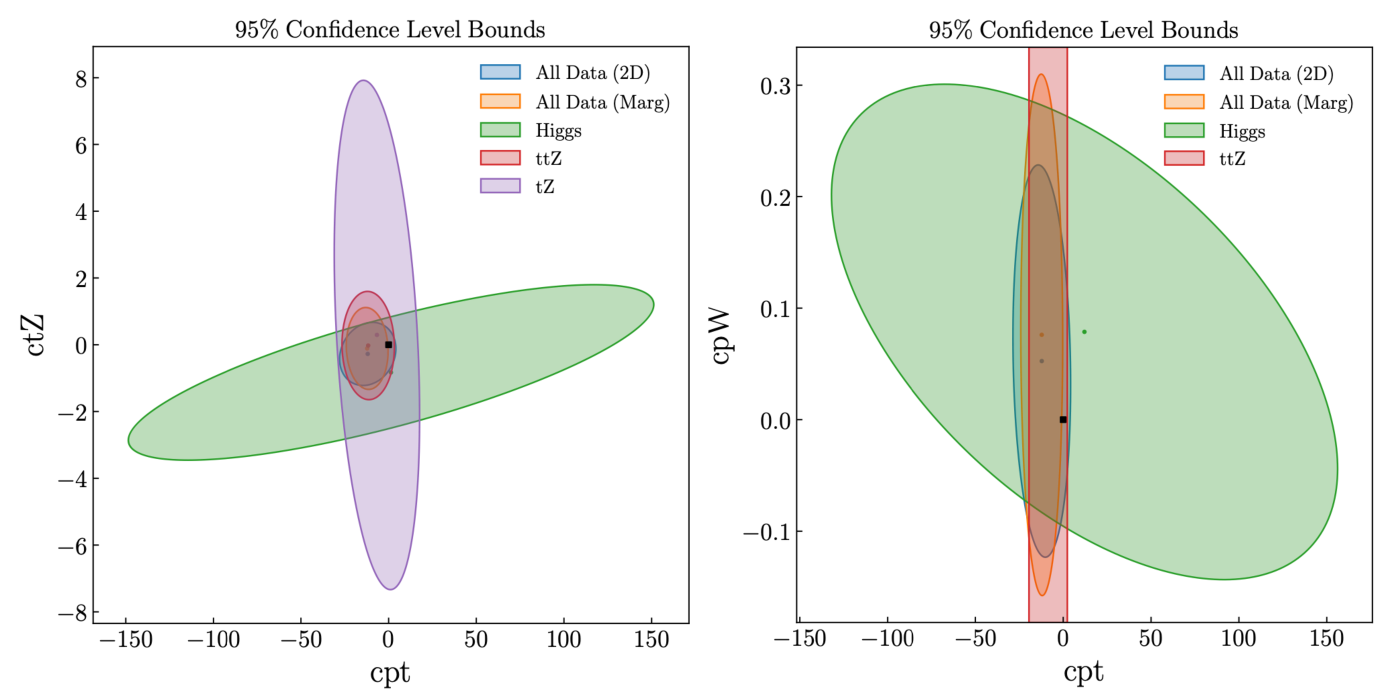
Samples from prior space to locate maximum. No need for optimisers.
Construct posterior distribution.

## Results: Higgs-top interplay




Comparison of the 95% CL bounds in the Higgs only and the global fit. We observe the main benefits of the simultaneous mapping of the EFT parameter space: in a Higgs-only fit a large number of coefficients are poorly constrained, in particular those involving fermion bilinears.

## Gain insight: 2D fits




To complement the insights provided by global fits, it can also be instructive to carry out two-parameter fits, especially to investigate the relative interplay between specific pairs of EFT coefficients. These comparisons illustrate the relative impact of the various datasets in constraining each coefficient.

## Outlook

- Add new data: Tevatron, VBS, low energy observables, future LHC measurements.
- Improve theory: be more systematic in including NLO QCD and EW, RGEs for low energy data.
- Improve fit methodology: larger number of parameters require better efficiency.

SMEFiT

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