Introductory slides

reusing slides from the presentations at the HXSWG Offshell Meeting on 25 Nov 2019

Indico link
SMEFT basics

New Interactions of SM particles

\[ \mathcal{L}_{EFT} = \mathcal{L}_{SM} + \sum_i \frac{C_i^{(6)} O_i^{(6)}}{\Lambda^2} + \mathcal{O}(\Lambda^{-4}) \]

Grzadkowski et al arXiv:1008.4884
Off-shell production in the SMEFT

The signal

The background

The Higgs width
The constraints on top operators

Monte Carlo implementation based on:
• Warsaw basis
• Degrees of freedom for top operators as in arXiv:1802.07237 (LHCTopWG)

Current status:
• 73 degrees of freedom (top, Higgs, gauge):
  • CP-conserving
  • Flavour assumption: $U(2)^Q \times U(2)^u \times U(3)^d \times U(3)^L \times U(3)^e$
• 0/2F@NLO operators validated (with previous partial NLO implementations)
  [Link](http://feynrules.irmp.ucl.ac.be/wiki/SMEFTatNLO)
• 4F@NLO operators validation: on-going

Future plans
• Full NLO model release (4F@NLO)
• Other flavour assumptions
• CP-violating effects

Work in progress with: C. Degrande, G. Durieux, F. Maltoni, K. Mimasu, C. Zhang
Results of combination for HL - LHC

Azatov, Grojean, Paul, Salvioni (2016/18)

double Higgs from 1502.00539; H+j from 1405.4295, inclusive and tth from ATL-PHYS-PUB-2013-014
Fit with only $O_y$ and $O_g$ operators

The degeneracy becomes even worse if we add the following operator to the lagrangian:

$$\mathcal{L}_6 = c_y \frac{y_t|H|^2}{v^2} \bar{Q}_L \tilde{H} t_R + \text{h.c.} + \frac{c_g g_s^2}{48 \pi^2 v^2} |H|^2 G_{\mu\nu} G^{\mu\nu} + \frac{c_g g'^2}{18 \pi^2 v^2} |H|^2 B_{\mu\nu} B^{\mu\nu}$$

Modification of the Higgs interactions to gluons and to photons are controlled by $c_y - c_g$
(3) anomalous HVV couplings (EFT)

- tested anomalous HVV couplings (production and decay)

\[ \frac{d \sigma_{gg \rightarrow H \rightarrow ZZ}}{d m_{ZZ}^2} \sim \frac{g_{ggH}^2 g_{HZZ}^2}{(m_{ZZ}^2 - m_H^2)^2 + m_H^2 \Gamma_H^2} \]

(1) not much effect on \( \Gamma_H \)

(2) constrain couplings given \( \Gamma_H \) or profile \( \Gamma_H \)
Count the number of EFT parameters in the Higgs basis

- Higgs HVV basis is ideal for off-shell studies
  - does not mix physical states $Z, \gamma, W$ to non-physical $B, W^0, W$
  - off-shell effect is interplay of $Z^*$ (or $W^*$) vs $H^*$
  - it is always possible to rotate the basis in the end

- Reduce to 4 HVV and 2 Hgg EFT couplings

on CMS also set $g^W_W = g^Z_Z$ ($\iff c_w = 1$ in EFT relationship)