Proposal for the validation of Monte Carlo implementations of the standard model effective field theory

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Abstract

We propose a procedure to cross-validate Monte Carlo implementations of the standard model effective field theory. It is based on the numerical comparison of squared amplitudes computed at specific phase-space and parameter points in pairs of implementations. Interactions are fully linearised in the effective field theory expansion. The squares of linear effective field theory amplitudes and their interference with standard-model contributions are compared separately. Such pairwise comparisons are primarily performed at tree level and a possible extension to the one-loop level is also briefly considered. We list the current standard model effective field theory implementations and the comparisons performed to date.

1

1 Introduction

This note proposes a procedure to validate Monte Carlo (MC) implementations —more or less partial— of the standard model effective field theory (SMEFT). The underlying agreement was achieved under the auspices of the LHC Top and Electroweak Working Groups, and of the LHC Higgs Cross Section Working Group.

Most of the existing MC implementations are able to compute leading-order predictions. Therefore, we primarily consider tree-level calculations. Many implementations are based on Lagrangians written in codes such as SARAH [1] or FEYNRULES [2] and then exported through standard format to matrix-element-based MC generators. A systematic procedure for comparing MC implementations is outlined through the comparison of squared amplitudes.

2 Existing implementations

A brief list of public SMEFT implementations with links and references is provided below. It shall be updated as new implementations become available.

- DIM6TOP is a UFO implementation of top-quark interactions following the conventions of the LHC top Working Group [3]. It is available at this url[1].

- SMEFTSIM is a complete UFO implementation of the Warsaw basis [4] of dimension-six operators [5]. It is available at this url[2].

- SMEFT@NLO is a UFO implementation, to next-to-leading order in QCD, of of CP- and $U(2)_q \times U(2)_u \times U(3)_d \times U(3)_l \times U(3)_e$-conserving dimension-six interactions, available at this url[3].

- SMEFTFR [6, 7] is a package generating Feynman rules, in FEYNRULES and UFO formats, for the dimension-six operators of the Warsaw basis [4] (or any subset), in unitary or linear R_ξ gauges, in terms of physical fields (mass eigenstates), for general flavour structures. It is available at this url[4].

- HEL [8] is an implementation of dimension-six operators in the SILH basis [9] available at this url[5].

- BSMC [10] is an implementation of dimension-six operators in the Higgs basis [11] associated with the ROSETTA package (here[6]). It is available at this url[7].

- POWHEG SM-EFT [12] is an implementation of SMEFT corrections to neutral and charged current Drell-Yan and electroweak Higgs boson production, including next-to-leading order QCD corrections and interfaced with parton showering and hadronization according to the POWHEG method. It is available at this url[8].

- RECOLA2 is a tree-level and one-loop matrix-element provider. While RECOLA [13, 14] was specifically designed for the SM, RECOLA2 [15, 16] can be linked against any user-provided model file. For the present comparison, a tree-level model containing the full set of dimension-six operators in the Warsaw basis was implemented. A preliminary version of the model was used in ref. [17] to study the impact of the dimension-six operators contributing to anomalous triple-gauge-boson interactions in vector-boson pair production at the LHC.

- SFITTER is a general purpose fitting tool that combines a large number of experimental channels in a global fit to constrain dimension-six operators in the HISZ basis. The basis is implemented in a UFO file and processed by MADGRAPH5, yielding parametrizations of experimental observables in terms of the Wilson coefficients. This implementation, extensively validated internally, is not public.

- HIGGSPO is a UFO implementation of the Higgs pseudo-observables framework at next-to-leading order in QCD [18–20], available at this url[9].

3 Validation procedure

The cross-validation of MC implementations of new physics models is in general a very time-consuming exercise, especially in the case of EFTs which feature large number of new interactions and parameters. In addition, as existing implementations rely on different operator bases, conventions and tools, a flexible, robust and scalable approach needs to be employed. The main idea of our proposal is to use physical predictions as terms of comparison. These are by definition independent of a certain number of conventions, and can be uniquely defined once the input parameters, the scheme employed and the order of the computations are set.

A first possibility is to compare total cross sections for producing given final states. Cross sections have the advantage of being easily obtainable in any MC framework. Such procedure was for example applied in ref. [3] for cross-validating the implementations of the top-quark sectors in SMEFTsim and dim6top frameworks. However, total cross sections are intrinsically limited by the numerical precision of the phase-space integration, which in some cases can entail considerable computing time. For example, to test operators involving four top quarks, processes such as $pp \to t\bar{t}t\bar{t}$ have to be considered and corresponding cross sections computed. We therefore adopt here a much leaner strategy that has been employed successfully in the past to compare models in FEYNRULES [2] with native ones in generators such as MADGRAPH5 [21], SHERPA [22], WHIZARD [23], HERWIG++ [24], CALCHEP [25] and FEYNARTS/FORMCALC [26, 27].

We propose the following validation procedure:

1. Comparisons are performed between pairs of models, at a series of parameter points.

   One may not aim at a fully connected network of n model with n^2 comparisons, a sparser one may be sufficient. It is expected that families of similar implementations that are easier to compare among themselves will form.

2. SM and EFT predictions are primarily considered at the tree level (see section 4 for an extension to the one-loop level).

3. The same set of electroweak input parameters is to be used in both models when comparing operators that shift them. Masses (m_Z and m_W) are included as input parameters to avoid SMEFT corrections to propagators that are not easy to treat in MC programs.

   Standard numerical values are input parameters for instance $\{G_F = 1.16637 \cdot 10^{-5} \, \text{GeV}^{-2},$ $m_Z = 91.1876 \, \text{GeV}, m_W = 80.379 \, \text{GeV}, m_h = 125 \, \text{GeV}, m_t = 172 \, \text{GeV}, \alpha_S(m_Z) = 0.1184\}$.

   We also suggest to fix the CKM matrix to unity, unless another scheme is adopted between the two models compared.

4. Particle widths are explicitly set to zero in the comparison, to avoid differences due to gauge choices in the two models. SMEFT corrections to propagators, that are not easy to treat for MC programs, would otherwise again be generated.

   The dependence of decay amplitude squared on EFT parameters could also be explicitly examined through one-to-n squared amplitudes. One may also adopt the complex mass scheme in the future.

5. The couplings of EFT vertices are linearised in the C/Λ^2 expansion. A linearisation of all internal parameters (such as coupling constants, the Higgs vev, electroweak inputs, etc.) and of their functions (denominators, square roots, power, etc.) is in particular required. This allows for the isolation by MC programs of amplitudes themselves linear in this expansion. Equivalent parameter points in different implementations are then also obtained through a linear mapping.

6. The computation of a set of two-to-n (and one-to-two) squared amplitudes, averaged over initial colours and helicities, summed over final ones, is performed at given phase space points (which may not necessarily physically representative). Numerical values are quoted in units of GeV to the appropriate power.

In the future, one could consider comparing helicity amplitudes squared.

When targetting Higgs or top-quark EFT interactions, the set of all SM two-to-two processes (excluding crossing-symmetric and conjugates) involving at least one of these particles can for instance be considered for comparisons, together with selected two-to-three processes like `g g > t t~ h` and `q q~ > q q~ h/a/z/w` processes (see table 2).

7. In addition to the SM contribution $|A_{\mathrm{SM}}|^2$, the interference $2\,\mathrm{Re}\{A_{\mathrm{SM}}^* A_{\mathrm{EFT}}\}$ and squared $|A_{\mathrm{EFT}}|^2$ EFT contributions are evaluated for equivalent parameter points in the two models.

   Although the $|A_{\mathrm{EFT}}|^2$ contributions do not constitute complete EFT results to $1/\Lambda^4$ order, they are unambiguously defined (since they arise from the square of leading EFT contributions at the amplitude level which are themselves unambiguously defined) and useful for the comparison of implementations, in particular in cases where the $2\,\mathrm{Re}\{A_{\mathrm{SM}}^* A_{\mathrm{EFT}}\}$ interference vanishes.

   Considered parameter points may for instance correspond to one single operator coefficient set to a non-vanishing value in one of the two models compared. One should then remember to check the relative sign of operators having vanishing interferences with the SM model by considering parameter points where two of them are non vanishing. Establishing sets of equivalent parameter points in implementations relying on different operator bases may require some effort.

8. Information about the implementations compared, parameter points, phase-space points, and averaged squared amplitudes are stored in LHE format (see v1 [28], v2[10] [29] and v3[11] descriptions).

   Information about the generators, model versions, processes and parameter points used to compute the amplitude squared corresponding to a given `id` are provided under the standard `<weight>` header (see table 1 for an example). The generator version used is specified in a `<weight_generator>` sub-header, the model version in a `<weight_model_version>` one. The date at which a UFO model has been generated can for instance be specified here to be as specific as possible. Information about the generated processes (numbered), the coupling order restrictions, etc. are specified in a generator-dependent format in a `<weight_card>` sub-header. The parameter point is provided in SLHA format in a `<weight_slha>` sub-header.

   The `<event>` field is used to store the phase-space point at which squared amplitudes are evaluated. The values of the latter for every `id` specified earlier are stored in a `<wgt>` field. The `id` label can be chosen to be human-readable and to include, separated by hyphens, information about the implementation, the parameter point, and a `sq` or `int` label specifying whether it corresponds to a squared or interference term (see again table 1 for an example).

9. Cross-validations realized by model authors will be referenced in section 5 of this note. Existing LHE files can serve as basis of comparison for additional models and be complemented with the numerical values they give rise to.

10. Comparison authors are encouraged to implement the basis translation(s) established in the public tools ROSETTA [10] (available at this url[12]) and WCXF-PYTHON [30] (available at this url[13]). Such tools can then be used to generate SLHA inputs for equivalent parameter points. Note that basis translations should be kept linear in the EFT expansion to comply with item 5.

4 Extension to the one-loop level

Relying on the BLHA [31, 32] conventions for loop amplitude providers, one can also extend the comparison of SMEFT amplitudes to the loop level.

```
<LesHouchesEvents version="3.0">
  <header>
    ...
    <initrwgt>
      <weightgroup name='mg_reweighting' weight_name_strategy='includeIdInWeightName'>
        <weight id='mod1-sm-sq'>
          <weight_generator>MadGraph5_aMC@NLO_v2.6.5</weight_generator>
          <weight_model-version>dim6top_LO_UFO v1.0 Sat 8 Dec 2018 14:17:45</weight_model_version>
          <weight_card>
            change model SMEFTsim_A_general_MwScheme_UFO_v2-sm
            change process  g g > t~ t FCNC=0 QED<=99 QCD<=99 NP=0 @1
            change process  g a > t~ t FCNC=0 QED<=99 QCD<=99 NP=0 @2
            change process  g t > z  t FCNC=0 QED<=99 QCD<=99 NP=0 @3
            ...
          </weight_card>
          <weight_slha>
            Block EFT
               22 0. # ctB
               23 0. # ctW
               ...
          </weight_slha>
        </weight>
        <weight id='mod1-ctW-int'>
          <weight_generator>MadGraph5_aMC@NLO_v2.6.5</weight_generator>
          <weight_model_version>dim6top_LO_UFO v1.0 Sat 8 Dec 2018 14:17:45</weight_model_version>
          <weight_card>
            change model SMEFTsim_A_general_MwScheme_UFO_v2-ctW
            change process  g g > t~ t FCNC=0 QED<=99 QCD<=99 NP<=1 NP^2==1 @1
            change process  g a > t~ t FCNC=0 QED<=99 QCD<=99 NP<=1 NP^2==1 @2
            change process  g t > z  t FCNC=0 QED<=99 QCD<=99 NP<=1 NP^2==1 @3
            ...
          </weight_card>
          <weight_slha>
            Block EFT
               22 0. # ctB
               23 1. # ctW
               ...
          </weight_slha>
        </weight>
        ...
      </weightgroup>
    </initrwgt>
  </header>
  ...
  <event>
      4    2 +5.7925728e-01 9.11180000e+01 0.00000000e+00 1.18400000e-01
          21 -1    0    0    0    0 +0.00e+00 +0.00e+00 +5.00e+02 5.00e+02 0.00e+00 0.00e+00 9.00e+00
          22 -1    0    0    0    0 +0.00e+00 +0.00e+00 -5.00e+02 5.00e+02 0.00e+00 0.00e+00 9.00e+00
          -6  1    1    2    0    0 +1.66e+02 -3.90e+02 +2.01e+02 5.00e+02 1.72e+02 0.00e+00 9.00e+00
           6  1    1    2    0    0 -1.66e+02 +3.90e+02 -2.01e+02 5.00e+02 1.72e+02 0.00e+00 9.00e+00
    <rwgt>
    <wgt id='mod1-sm-sq'> +2.1166989e-01 </wgt>
    <wgt id='mod1-ctW-int'> +3.6769585e-01 </wgt>
    <wgt id='mod1-ctZ-int'> -3.2187585e-01 </wgt>
    <wgt id='mod1-ctG-int'> +3.0451935e-02 </wgt>
    <wgt id='mod1-ctW-sq'> +1.5438777e+00 </wgt>
    <wgt id='mod1-ctZ-sq'> +1.1830749e+00 </wgt>
    <wgt id='mod1-ctG-sq'> +1.0589251e-02 </wgt>
    <wgt id='mod2-sm-sq'> +2.1166988e-01 </wgt>
    <wgt id='mod2-ctW-int'> +3.6769591e-01 </wgt>
    <wgt id='mod2-ctZ-int'> -3.2187587e-01 </wgt>
    <wgt id='mod2-ctG-int'> +3.0451934e-02 </wgt>
    <wgt id='mod2-ctW-sq'> +1.5438783e+00 </wgt>
    <wgt id='mod2-ctZ-sq'> +1.1830750e+00 </wgt>
    <wgt id='mod2-ctG-sq'> +1.0589251e-02 </wgt>
    ...
    </rwgt>
  </event>
  ...
</LesHouchesEvents>
```

Table 1: Example of LHE format (based on the SLHA3 convention) including headers specifying the EFT implementations, processes (numbered with @i in MADGRAPH syntax), parameter points. The event record relative to a given process and parameter point specifies the phase-space point and the averaged squared amplitudes obtained for the specified implementations, parameter points and EFT order.

```
   Higgs              top           two-to-three      c u~ > c d~ w-    d c~ > d s~ w-    b b~ > t b~ w-
g g > g h          g g > t~ t       g g  > t t~ h     c u~ > s d~ g    d d~ > d d~ g    b b~ > t t~ g
g g > h h          g b > w- t       u u~ > u u~ g     c u~ > s d~ a    d d~ > d d~ a    b b~ > t t~ a
g u > u h          g a > t~ t       u u~ > u u~ a     c u~ > s d~ z    d d~ > d d~ z    b b~ > t t~ z
g c > c h          g t > z t        u u~ > u u~ z     c u~ > s d~ h    d d~ > s s~ g    b b~ > t t~ h
g d > d h          u b > d t        u u~ > u u~ h     c c~ > c c~ g    d d~ > s s~ a    b t~ > t t~ w-
g s > s h          u u~ > t~ t      u u~ > u d~ w-    c c~ > c c~ a    d d~ > s s~ z    t b~ > t t~ w+
g b > b h          c b > s t        u u~ > c c~ g     c c~ > c c~ z    d d~ > b b~ g    t t~ > t t~ g
g t > t h          c c~ > t~ t      u u~ > c c~ a     c c~ > c c~ h    d d~ > b b~ a    t t~ > t t~ a
u u~ > a h         d d~ > t~ t      u u~ > c c~ z     c c~ > c s~ w-   d d~ > b b~ z    t t~ > t t~ z
u u~ > z h         s s~ > t~ t      u u~ > c c~ h     c c~ > d d~ g    d d~ > b b~ h    t t~ > t t~ h
u d~ > w+ h        b b~ > t~ t      u u~ > c s~ w-    c c~ > d d~ a    d d~ > b t~ w+
c c~ > a h         b a > w- t       u u~ > d u~ w+    c c~ > d d~ h    d d~ > t b~ w-
c c~ > z h         b ve > e- t      u u~ > d d~ g     c c~ > s c~ w+   d d~ > t t~ g
c s~ > w+ h        b vm > mu- t     u u~ > d d~ a     c c~ > s s~ g    d d~ > t t~ a
d u~ > w- h        b vt > ta- t     u u~ > d d~ z     c c~ > s s~ z    d d~ > t t~ z
d d~ > a h         b z > w- t       u u~ > d d~ h     c c~ > s s~ h    d d~ > t t~ h
d d~ > z h         a a > t~ t       u u~ > s c~ w+    c c~ > b b~ g    s c~ > s s~ w-
s c~ > w- h        a t > z t        u u~ > s s~ g     c c~ > b b~ a    s c~ > b b~ w-
s s~ > a h         ve ve~ > t~ t    u u~ > s s~ a     c c~ > b b~ z    s c~ > b t~ g
s s~ > z h         vm vm~ > t~ t    u u~ > s s~ z     c c~ > b b~ h    s c~ > b t~ a
b b~ > a h         vt vt~ > t~ t    u u~ > s s~ h     c c~ > b t~ w+   s c~ > b t~ z
b b~ > z h         e- e+ > t~ t     u u~ > b b~ g     c c~ > t b~ w-   s c~ > b t~ h
b t > w- h         mu- mu+ > t~ t   u u~ > b b~ a     c c~ > t t~ g    s c~ > t t~ w-
b~ t > w+ h        ta- ta+ > t~ t   u u~ > b b~ z     c c~ > t t~ a    s s~ > s s~ g
a a > h h          t t > t t        u u~ > b b~ h     c c~ > t t~ z    s s~ > s s~ a
a ve > ve h        t z > z t        u u~ > b t~ w-    c c~ > t t~ h    s s~ > s s~ z
a vm > vm h        t w+ > w+ t      u u~ > t t~ g     c d~ > s d~ w+   s s~ > s s~ h
a vt > vt h                         u u~ > t t~ a     c s~ > s s~ w+   s s~ > b b~ g
a e- > e- h                         u u~ > t t~ z     c s~ > b b~ w+   s s~ > b b~ a
a mu- > mu- h                       u u~ > t t~ h     c s~ > t b~ g    s s~ > b b~ z
a ta- > ta- h                       u c~ > d c~ w+    c s~ > t b~ a    s s~ > b b~ h
a t > t h                           u c~ > d s~ g     c s~ > t b~ z    s s~ > b t~ w+
a z > h h                           u c~ > d s~ a     c s~ > t b~ h    s s~ > t b~ w-
a w+ > w+ h                         u c~ > d s~ z     c s~ > t t~ w+   s s~ > t t~ g
ve ve~ > z h                        u c~ > d s~ h     d u~ > d d~ w-   s s~ > t t~ a
ve e+ > w+ h                        u d~ > d d~ w+    d u~ > s s~ w-   s s~ > t t~ z
vm vm~ > z h                        u d~ > s s~ w+    d u~ > b b~ w-   s s~ > t t~ h
vm mu+ > w+ h                       u d~ > b b~ w+    d u~ > b t~ g    b b~ > b b~ g
vt vt~ > z h                        u d~ > t b~ g     d u~ > b t~ a    b b~ > b b~ a
vt ta+ > w+ h                       u d~ > t b~ a     d u~ > b t~ z    b b~ > b b~ z
e- ve~ > w- h                       u d~ > t b~ z     d u~ > b t~ h    b b~ > b b~ h
e- e+ > z h                         u d~ > t b~ h     d u~ > t t~ w-   b b~ > b t~ w+
mu- vm~ > w- h                      u d~ > t t~ w+
mu- mu+ > z h
ta- vt~ > w- h
ta- ta+ > z h
t t~ > z h
t t~ > h h
z z > h h
z w+ > w+ h
w+ h > w+ h
h h > h h
```

Table 2: Illustrative sets of two-to-two SM processes involving at least a Higgs or a top-quark which can be used as basis for a comparison. Examples of two-to-three processes including $gg \to t\bar{t}h$ and $q\bar{q} \to q\bar{q}\, g/\gamma/Z/W/h$ ones.

```
<LesHouchesEvents version="3.0">
  <header>
    <initrwgt>
      <weightgroup name='...' weight_name_strategy='...'>
        <weight id='...'>
          ...
          <weight_blha>
            InterfaceVersion        BLHA2
            MatrixElementSquareType  CHsummed
            CorrectionType          QCD
            IRregularisation        DREG
            WidthScheme             ComplexMass
            EWScheme                alphaGF
            AccuracyTarget          0.0001
            CouplingPower QCD       2
            CouplingPower QED       0
            mu                      91.188          # renormalization scale
          </weight_blha>
        </weight>
        ...
      </weightgroup>
    </initrwgt>
  </header>
  ...
  <event>
      4       2 +5.7925728e-01 9.11180000e+01 0.00000000e+00 1.18400000e-01
          21 -1    0    0    0    0 +0.00e+00 +0.00e+00 +5.00e+02 5.00e+02 0.00e+00 0.00e+00 9.00e+00
          22 -1    0    0    0    0 +0.00e+00 +0.00e+00 -5.00e+02 5.00e+02 0.00e+00 0.00e+00 9.00e+00
          -6  1    1    2    0    0 +1.66e+02 -3.90e+02 +2.01e+02 5.00e+02 1.72e+02 0.00e+00 9.00e+00
           6  1    1    2    0    0 -1.66e+02 +3.90e+02 -2.01e+02 5.00e+02 1.72e+02 0.00e+00 9.00e+00
    <rwgt>
    <wgt id='mod1-sm-sq'> (+2.1166989e-01, +3.6769585e-01, -3.2187585e-01) </wgt>
    <wgt id='mod1-ctW-int'> (+3.6769585e-01, +1.5438777e+00, +2.1166989e-01) </wgt>
    <wgt id='mod1-ctW-sq'> (+1.5438777e+00, -3.2187585e-01, +1.5438777e+00) </wgt>
    ...
    </rwgt>
  </event>
  ...
</LesHouchesEvents>
```

Table 3: Extension of the LHE formatting for one-loop processes. A `<weight_blha>` sub-header is added with BLHA information and the residues of ϵ poles are quoted in `<wgt>` fields as (PoleCoeff0, PoleCoeff1, PoleCoeff2) triplets.

A setup block denoted as `<weight_blha>` is added to the `<weight>` header. In addition to BLHA2 parameters the value of the renormalization scale `mu` is also specified. Following, for instance, the example provided in figure 6 of ref. [32], one would obtain a format like that of table 3.

Colour- and helicity-summed pole residues would then be specified in a (PoleCoeff0, PoleCoeff1, PoleCoeff2) triplet stored in `<wgt>` fields for each implementation, process, phase-space point, parameter point, and EFT order. The squared terms correspond here to loop amplitudes with one EFT operator insertion squared against tree amplitudes featuring also one EFT operator insertion.

As mentioned in item 6, one could consider comparing squared helicity amplitudes in the future.

5 Comparisons performed

A list of the comparisons performed between different implementations, according to the guidelines of this note, is provided here with references to their detailed discussion. It shall be updated as new comparisons become available.

- A comparison of top-quark interactions in DIM6TOP, SMEFTsim and SMEFT@NLO UFO models obtained with a dedicated MADGRAPH plugin are provided at this url[14]. More explanations are provided in this file[15].

- The RECOLA2 model file including the dimension-six operators in the Warsaw basis has been cross-checked against the SMEFTSIM_A_U35_MwScheme_UFO_v2_1 UFO model file for the subset of operators that only involve gauge bosons and/or scalars. The numerical results corresponding to the former model have been obtained with the RECOLA2 matrix-element provider, while MADGRAPH5_aMC@NLO was used for the latter model. A sample output file in the LHE format described above can be found at the url[16] for a few selected processes. As can be seen from the LHE file, the only differences between the predictions of the two models are some interference matrix-elements that however correspond to numerical zeros.

- A comparison of HEL and BSMC implementations is ongoing.

Links

[1] https://feynrules.irmp.ucl.ac.be/wiki/dim6top
[2] https://feynrules.irmp.ucl.ac.be/wiki/SMEFT
[3] https://feynrules.irmp.ucl.ac.be/wiki/SMEFTatNLO
[4] http://www.fuw.edu.pl/smeft
[5] https://feynrules.irmp.ucl.ac.be/wiki/HEL
[6] https://rosetta.hepforge.org
[7] http://feynrules.irmp.ucl.ac.be/wiki/BSMCharacterisation
[8] http://powhegbox.mib.infn.it/
[9] https://www.physik.uzh.ch/data/HiggsPO
[10] http://www.lpthe.jussieu.fr/LesHouches09Wiki/index.php/LHEF_for_Matching
[11] https://phystev.cnrs.fr/wiki/2013:groups:tools:lhef3
[12] https://rosetta.hepforge.org
[13] https://wcxf.github.io/python.html
[14] https://bazaar.launchpad.net/~rwgtdim6/mg5amcnlo/plugin_eft_contrib/revision
[15] https://bazaar.launchpad.net/~rwgtdim6/mg5amcnlo/plugin_eft_contrib/view/head:/example/compare_models_top.py
[16] https://recola.hepforge.org/modelfiles/smeftcmp.html

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