Personal Remarks on SMEFT for Snowmass

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Why do we want to use SMEFT ?

1. To estimate sensitivity to new physics

   if we would like to test to water for the sensitivity of a measurement to new physics we can add 1 SMEFT couplings and extract limits on the Λ scale

2. To provide a model needed to extract particle properties

   for the Higgs boson, the difficulty of measuring Γ_{tot} requires that we use such a model to quote absolute Higgs boson couplings

In both cases, the interpretation depends on the connection to explicit models of BSM physics. We need to know how

$$\frac{c_i}{\Lambda^2} \quad \text{or} \quad \frac{\Delta g(AAh)}{g(AAh)|_{SM}}$$

are related to the parameters of BSM models.

This is not obvious. This is especially true for

models of composite Higgs

should we set couplings to 1, to 4π ?

models of flavor violation

BSM must be constrained from general flavor violation, but we do not know what constraint nature is applying

In principle, the number of SMEFT parameters is infinite. So how can SMEFT be used as a model?

Usually, we restrict to dimension 6 operators only. This still gives a very large set of parameters unless we make further restrictions.

Here are some problematic aspects that require thought:

"energy helps accuracy": this can be a devil's bargain.

The SMEFT might not describe a real BSM model at very high Q^2. At some stage, the new particles of the BSM model come in and cut off the E^2/Λ^2 rise of BSM effects. Unitarity bounds provide guidance, but this is the most optimistic case.

Another test is whether linear dependence on SMEFT coefficients is adequate. Linear and nonlinear analyses should give the same answer, otherwise the conclusions are not valid.

“higher order helps accuracy”:

There can be a problem if higher order calculations bring in new SMEFT coefficients. In the analysis of Higgs couplings, dipole operators

$$Q\sigma_{\mu\nu}F^{\mu\nu}\Phi q_R$$

enter in 1-loop order. This brings in many new couplings with effects degenerate with couplings contributing at the tree level.

Similarly, loop effects bring in the huge number of 3rd generation SMEFT operators, which then must be separately constrained.

SMEFT parameters can contribute to backgrounds

At hadron colliders, where the extraction of the Higgs signal from background is a major issue, 4-fermion contact interactions can affect the predicted size of background processes.   How do we take this into account. Data driven estimates help here, but can these achieve very high accuracy?

If SMEFT is to be used as the most general model, should this model also include possible effects of sectors outside the SM?

This comes up explicitly in the question of how the possibility of exotic Higgs decays can be included in fits for Higgs couplings.

On the other hand, there are cases were

We are interested in quoting accuracy on pseudo-observables (Higgs couplings) rather than SMEFT parameters.

Many operators contribute, but their effects are not distinguishable. An example is dimension-6 effects on the on-shell hgg coupling.

Here we can accept the degeneracy; it is not significant for the measurement we wish to make.

Example: our 16+4+2-parameter analysis of Higgs couplings from e+e-.

I apologize that these remarks are rather off-the-cuff. It would be good to write a document that specifically addresses these non-obvious difficulties of SMEFT analysis and (maybe) suggests solutions to them.