Putting SMEFT Fits to Work

Global Fits and the “Higgs Inverse Problem”


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Energy Frontier Meeting Preparatory Joint Sessions
July 8, 2020
A Number of Global Fits in the Literature...

Important to remember that ultimately we’re looking for new physics!

How do we interpret these limits in the context of particular models?

See also:
Ellis et al., 1803.03252
Grojean et al., 1810.05149
da Silva Almeida et al., 1812.01009,
Biekotter et al., 1812.07587,
de Blas et al., 1905.03764
Strategy:

Integrate out new particles at matching scale (M ~ few TeV)

\[ \mathcal{L} \supset \lambda_3 \bar{Q}_L \tilde{H} T_R \]

Generate subset of SMEFT Coefficients

\[ (C^{(1)}_{Hq})_{33}, (C^{(3)}_{Hq})_{33}, C_{tH}, C_{HG} \]

Evolve Coefficients down to EW scale

\[ C_{HD}, C_{H\Box} \ldots \]

Fit to Higgs + Diboson + EWPO Data

Limits on physical parameters!

Example: \( T \) Vector-like Quark
SM + VLQ Singlet Mixing with Top

Generates $C_{tH}$, $(C_{Hq}^{(1)})_{33}$, $(C_{Hq}^{(3)})_{33}$, $C_{HG}$ at the matching scale

EWPO Constraints:

LHC Constraints:

LEP sensitivity via Z to $b\bar{b}$ — flat direction broken by RGEs

Note: NLO effects important for these diboson limits! (1909.11576)
SM + VLQ Singlet Mixing with Top

Generates $C_{tH}$, $(C_{Hq}^{(1)})_{33}$, $(C_{Hq}^{(3)})_{33}$, $C_{HG}$ at the matching scale

The T VLQ is a 1-parameter model — sweeps out only a line in this plane

\[
(C_{Hq}^{(1)})_{33} = -(C_{Hq}^{(3)})_{33} = \frac{1}{2Y_t} C_{tH}
\]

$\Lambda = 1 \text{ TeV}$

Parameters generated by the model
SM + VLQ Singlet Mixing with Top

Generates $C_{tH}, (C_{Hq}^{(1)})_{33}, (C_{Hq}^{(3)})_{33}, C_{HG}$ at the matching scale

(3, 1)$_{2/3}$ VLQ Mixing with Top Quark
SMEFT Fit

\[
\sin \theta_L
\]

$M_T(GeV)$
SM + VLQ Doublet Mixing with (t,b)

Generates $C_{bH}, C_{tH}, C_{Hb}, C_{Ht}, C_{Htb}, C_{HG}$ at the matching scale

**EWPO Constraints:**

**LHC Constraints:**

LEP sensitivity via Z to $bb$ — flat direction broken by RGEs

Strong constraint from RGE induced operators
SM + VLQ Doublet Mixing with (t,b)

Generates $C_{bH}$, $C_{tH}$, $C_{Hb}$, $C_{Ht}$, $C_{Htb}$, $C_{HG}$ at the matching scale

Model described by two parameters — mixing angle and mass splitting

\[ C_{tH} = -Y_t C_{Ht}, \quad C_{bH} = Y_b C_{Hb}, \quad C_{HG} = \frac{\alpha_s}{8\pi} 0.65 C_{Hb} \]

$\Lambda = 1 \text{ TeV}$
SM + VLQ Doublet Mixing with (t,b)

Generates $C_{bH}, C_{tH}, C_{Hb}, C_{Ht}, C_{Htb}, C_{HG}$ at the matching scale

Model described by two parameters — mixing angle and mass splitting

![Graph showing mixing angle and mass splitting](image-url)
SM + Singlet Scalar

Generates $C_H, C_H \square$ at the matching scale

$$O_H = (H^\dagger H)^3$$

Limits on the singlet from EWPO and LHC competitive — but most allowed coefficients cannot be generated in the model
Two Higgs Doublet Models

Generates $C_H, C_{bH}, C_{tH}, C_{\tau H}$ at the matching scale

2HDM limits come entirely from Higgs data
Different types of models sweep out wide range of allowed coefficients
Two Higgs Doublet Models

Generates $C_H, C_{bH}, C_{tH}, C_{\tau H}$ at the matching scale

Note that these are SMEFT Fits — not 2HDM fits!

Bounds can be reinterpreted in the usual physical parameter space. RGE effects slightly change the limits.
Key Takeaways:

- RG Evolution is crucial in interpreting coefficients in terms of models!
- Also important to keep flavor assumptions in mind (1911.07866)

Lots more work to do:

- More robust understanding what coefficients can be generated
- Understand linear vs. quadratic approximation in fits in context of models?
- Include complete one-loop matching, more NLO effects in fits, and more distributions
- Top data is important for many of our models too, and should be included in global fits