Stony Brook University

Putting SMEFT Fits to Work

Global Fits and the “Higgs Inverse Problem”

[arXiv:2007.01296]

Samuel Homiller

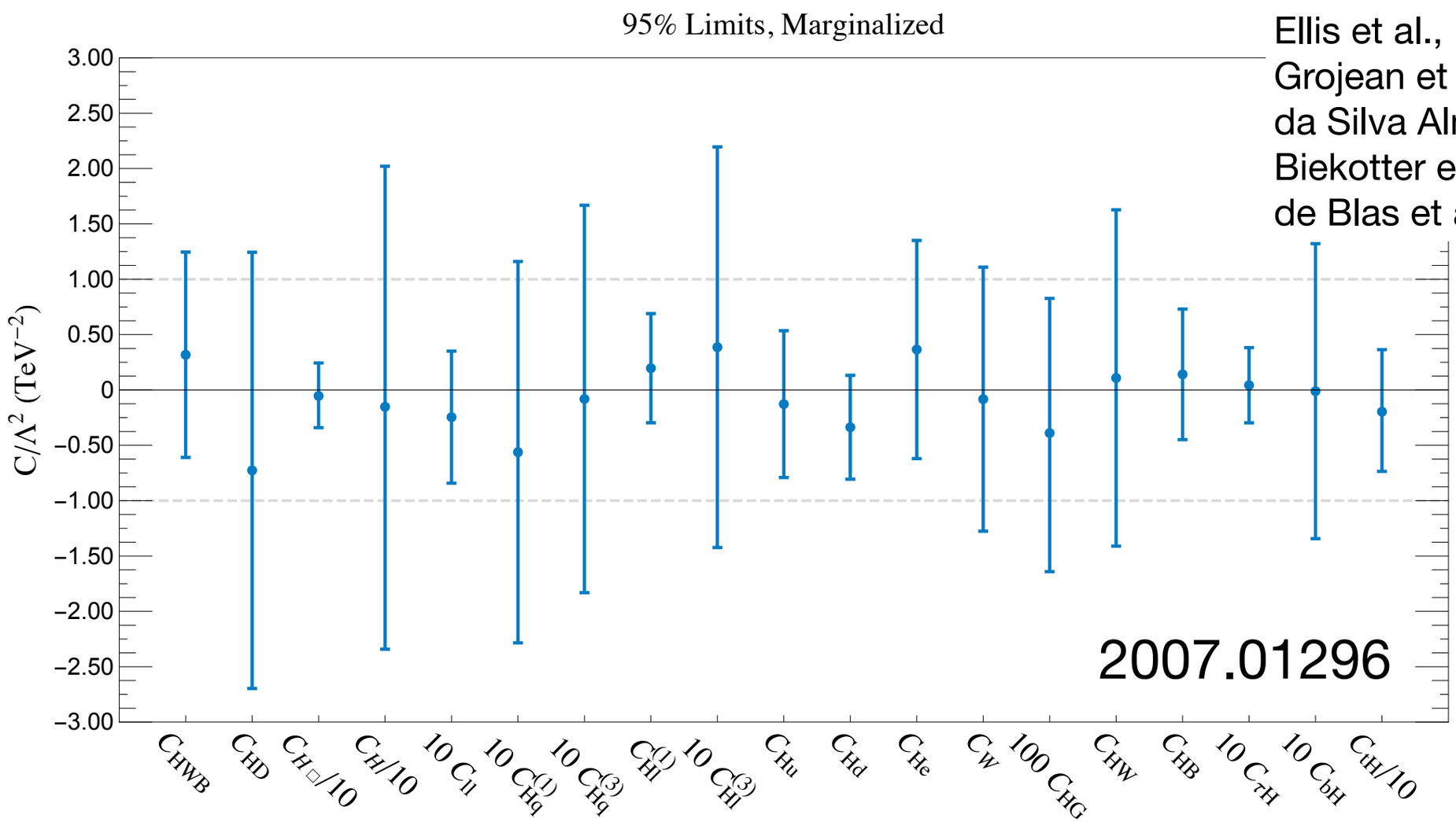
C. N. Yang Institute for Theoretical Physics

In collaboration with Sally Dawson & Samuel Lane

Energy Frontier Meeting Preparatory Joint Sessions
July 8, 2020

A Number of Global Fits in the Literature…

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



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

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

Strategy:

Example: *T* Vector-like Quark

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

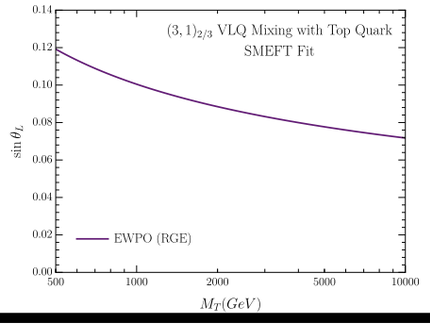
$$\left(C_{Hq}^{(1)}\right)_{33},\ \left(C_{Hq}^{(3)}\right)_{33},\ C_{tH},\ C_{HG}$$

Evolve Coefficients down to EW scale

$$C_{HD},\ C_{H\Box}\ \cdots$$

Fit to Higgs + Diboson + EWPO Data

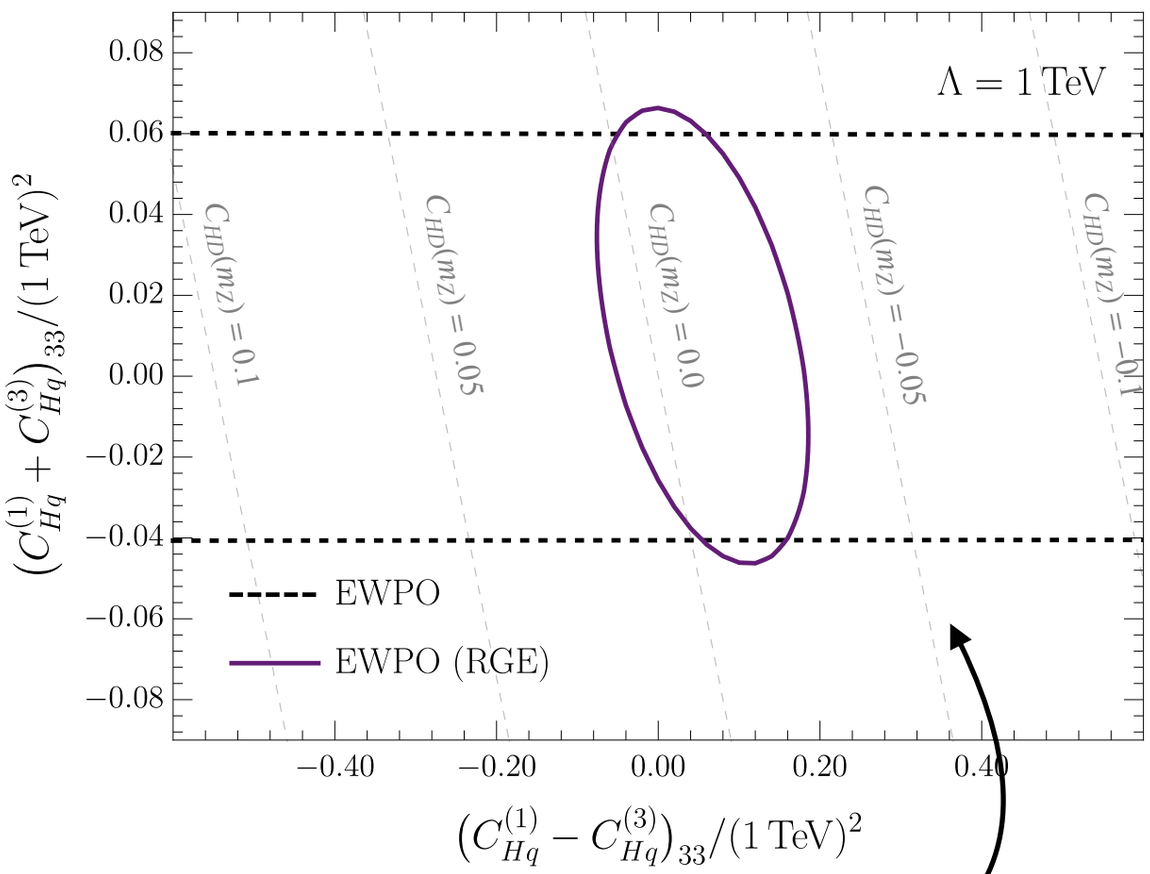
→ Limits on physical parameters!



SM + VLQ Singlet Mixing with Top

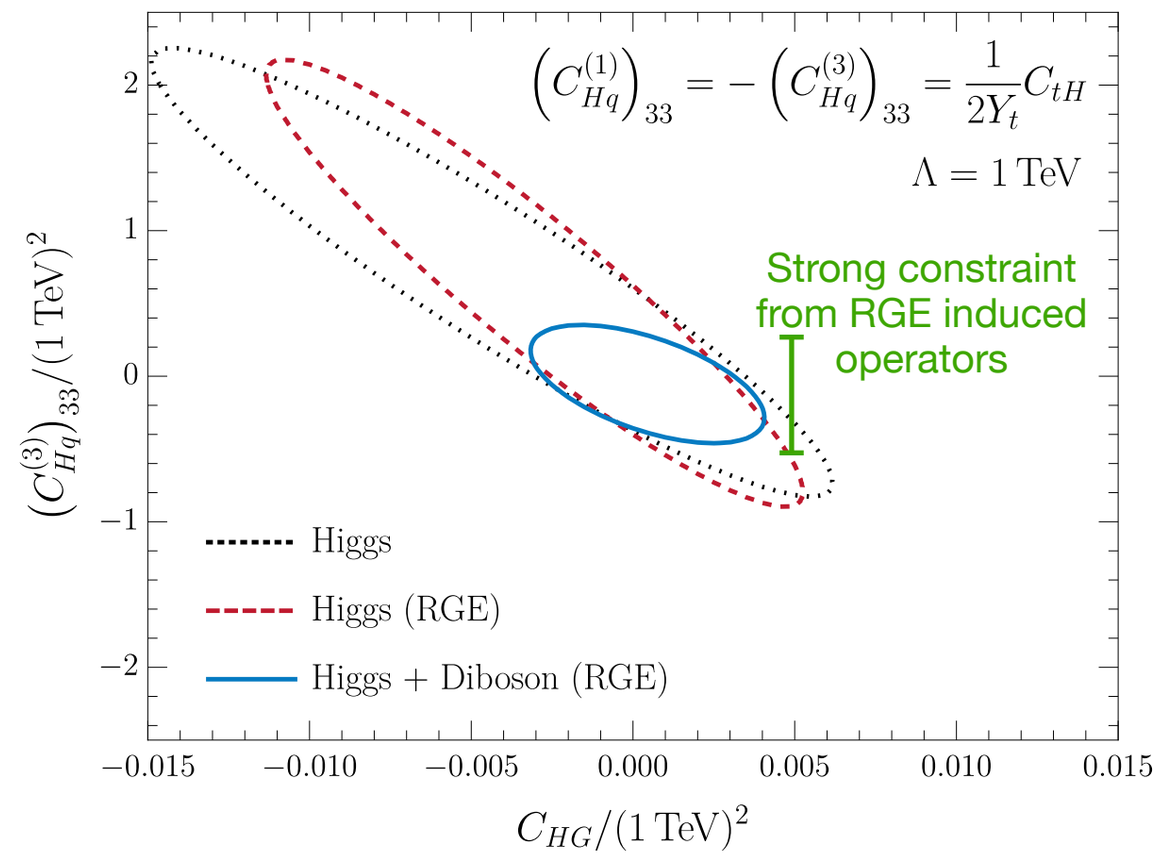
Generates C_{tH}, $\left(C_{Hq}^{(1)}\right)_{33}$, $\left(C_{Hq}^{(3)}\right)_{33}$, C_{HG} at the matching scale

EWPO Constraints:



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

LHC Constraints:

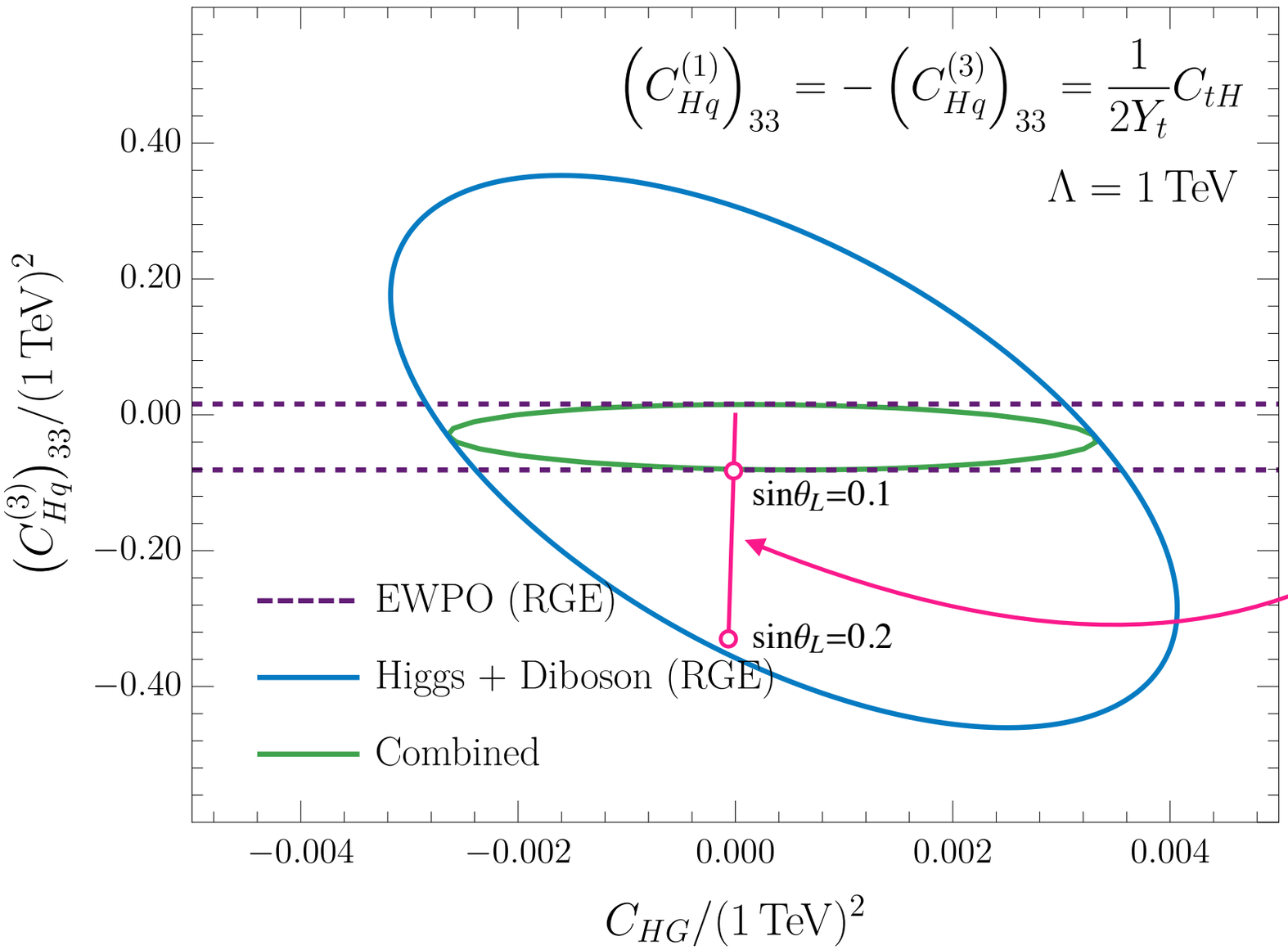


Note: NLO effects important for these diboson limits! (1909.11576)

SM + VLQ Singlet Mixing with Top

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

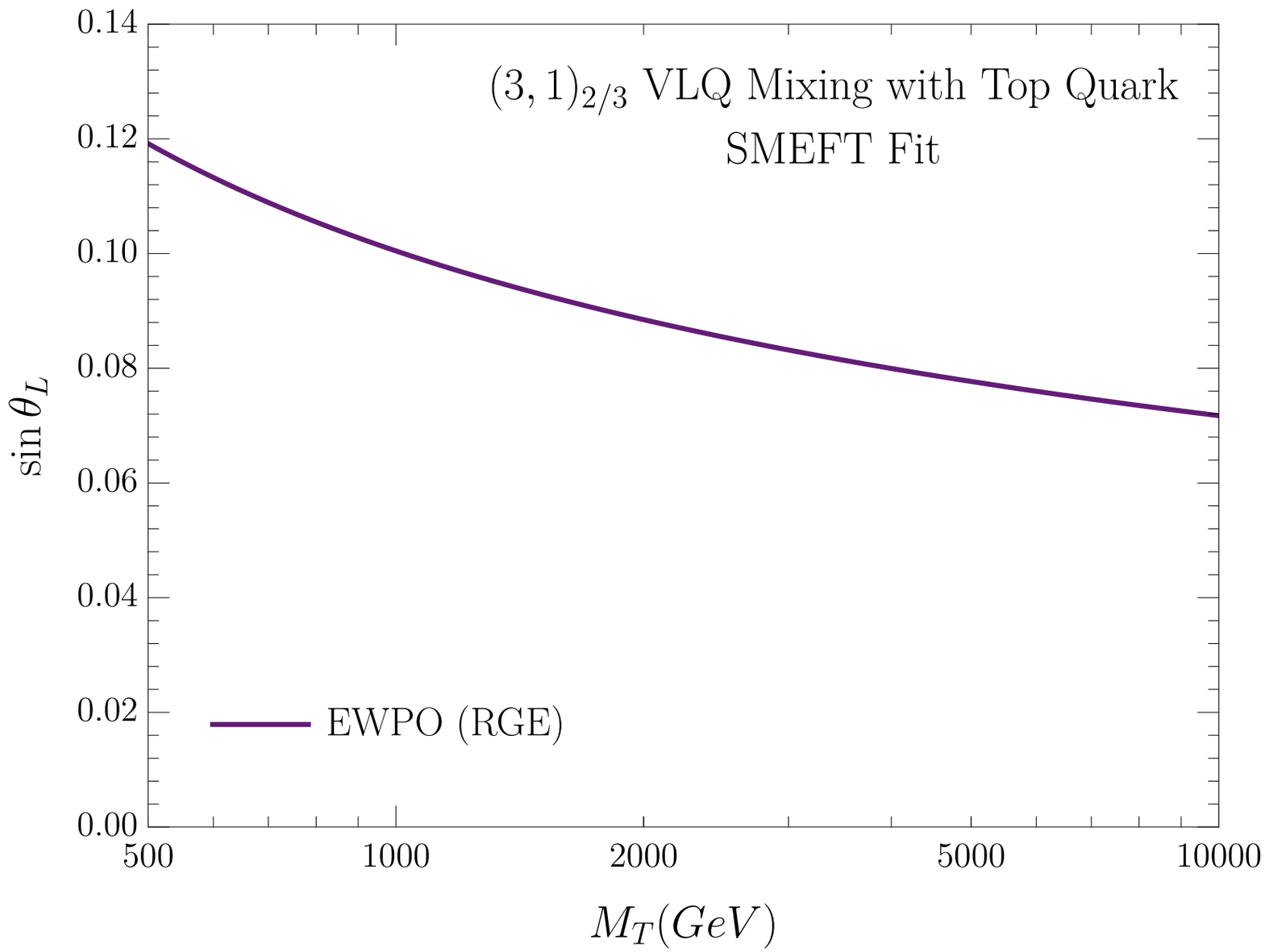
The T VLQ is a 1-parameter model — sweeps out only a line in this plane



Parameters generated by the model

SM + VLQ Singlet Mixing with Top

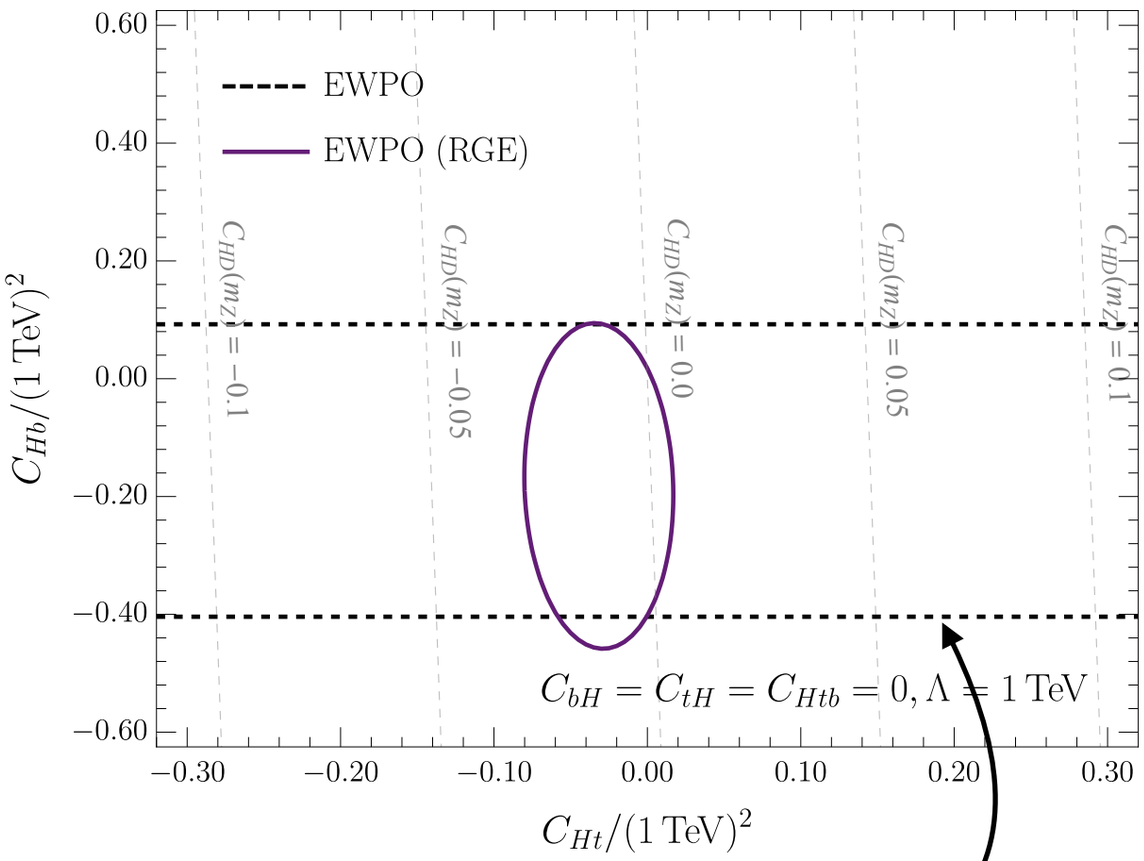
Generates C_{tH}, $\left(C_{Hq}^{(1)}\right)_{33}$, $\left(C_{Hq}^{(3)}\right)_{33}$, C_{HG} at the matching scale



SM + VLQ Doublet Mixing with (t,b)

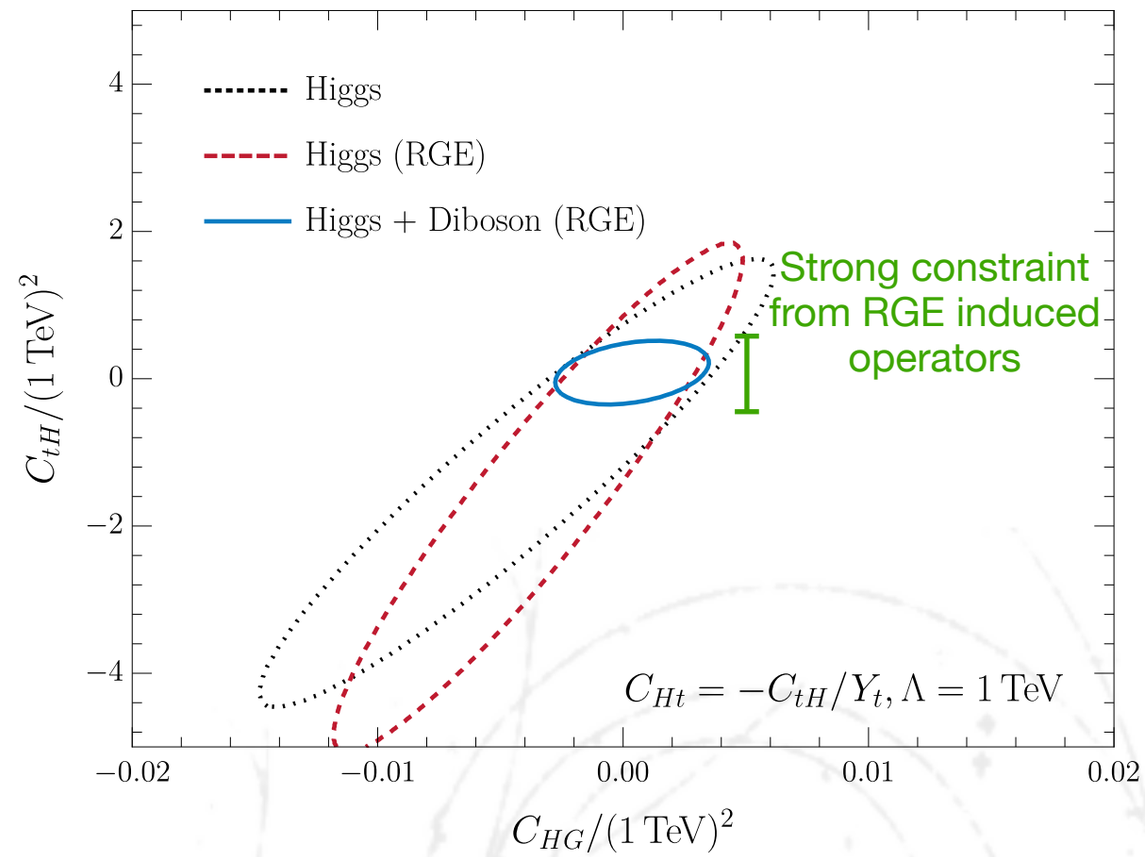
Generates C_{bH}, C_{tH}, C_{Hb}, C_{Ht}, C_{Htb}, C_{HG} at the matching scale

EWPO Constraints:



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

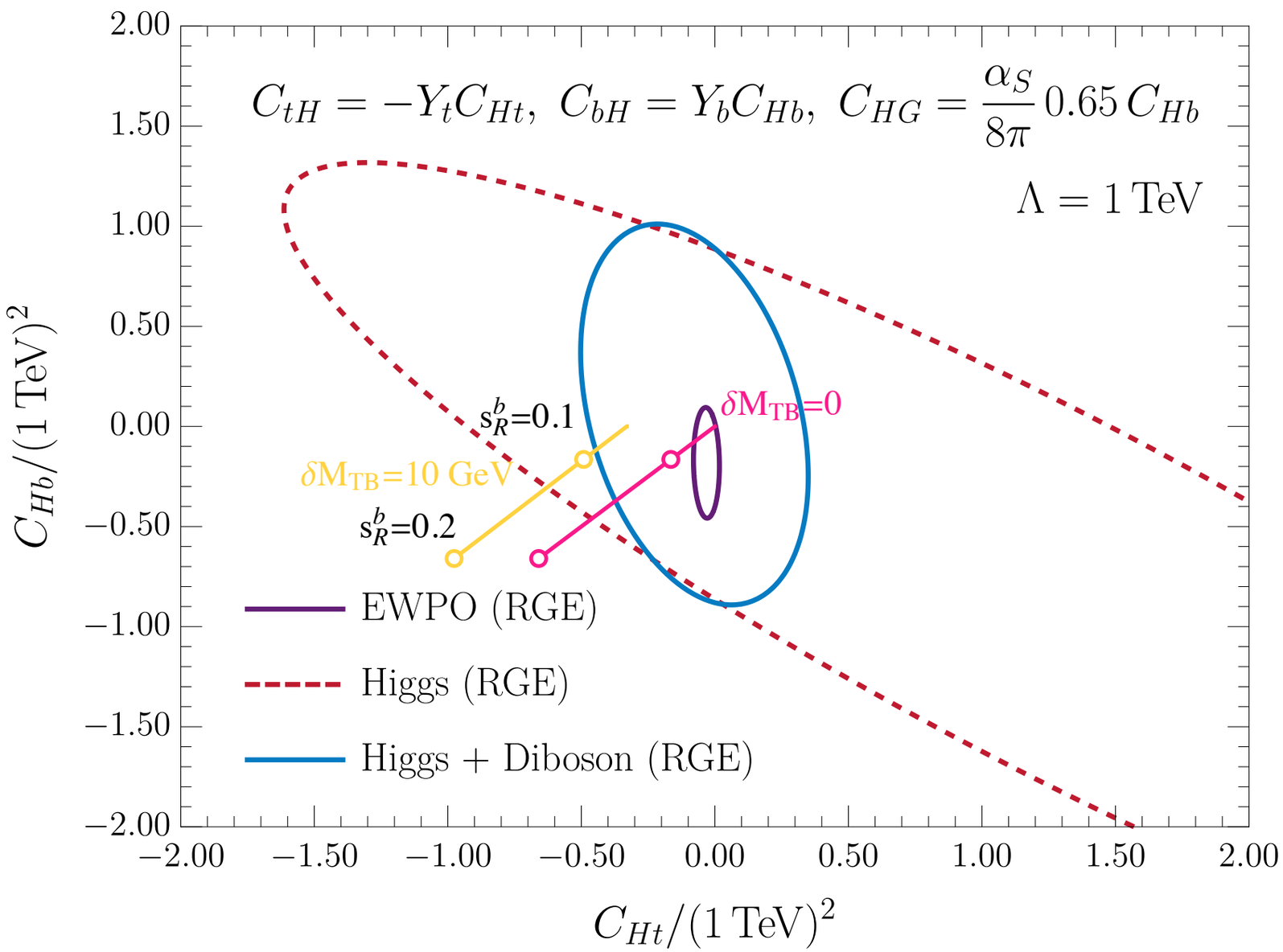
LHC Constraints:



SM + VLQ Doublet Mixing with (t,b)

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

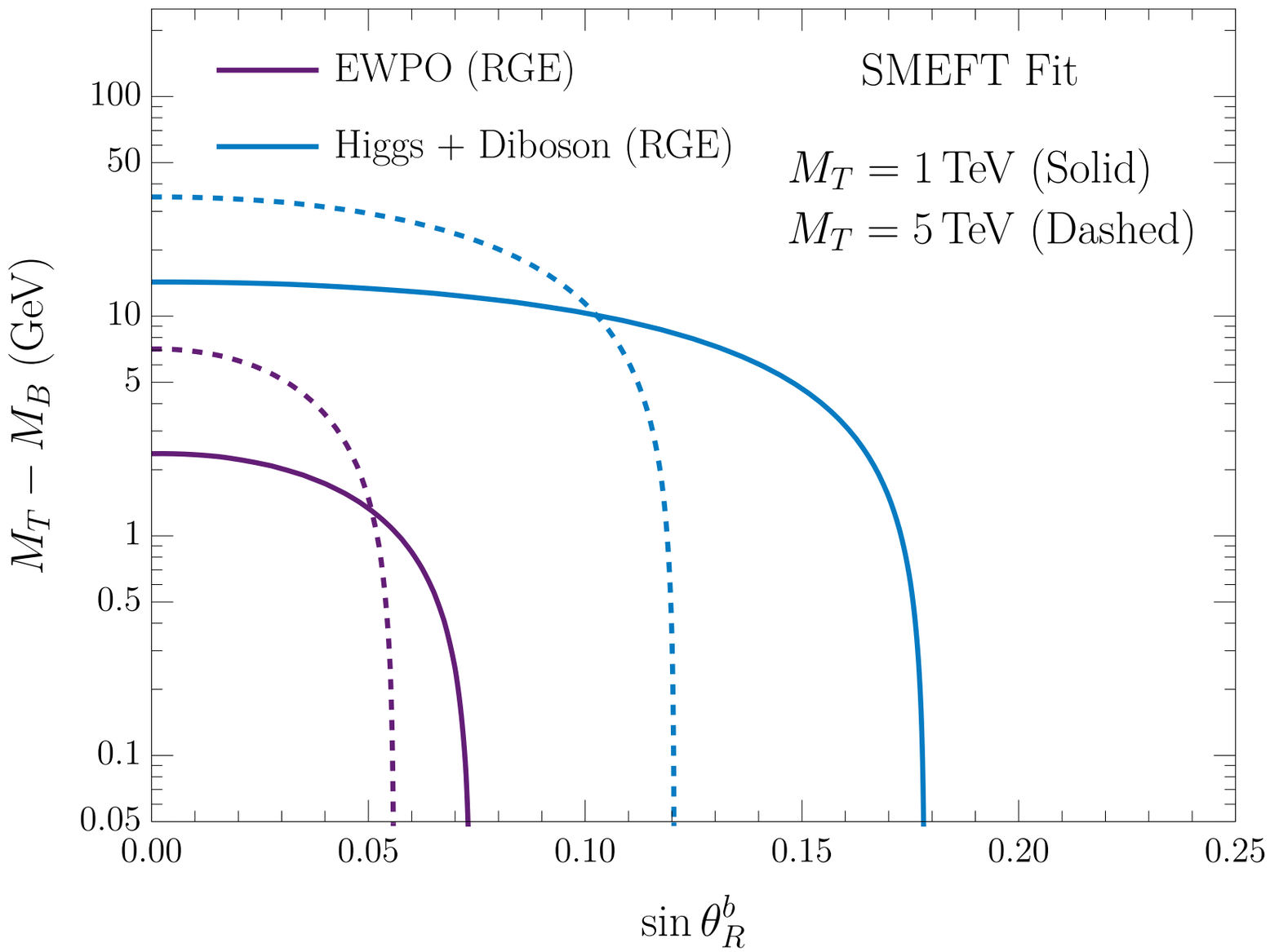
Model described by *two* parameters — mixing angle and mass splitting



SM + VLQ Doublet Mixing with (t,b)

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

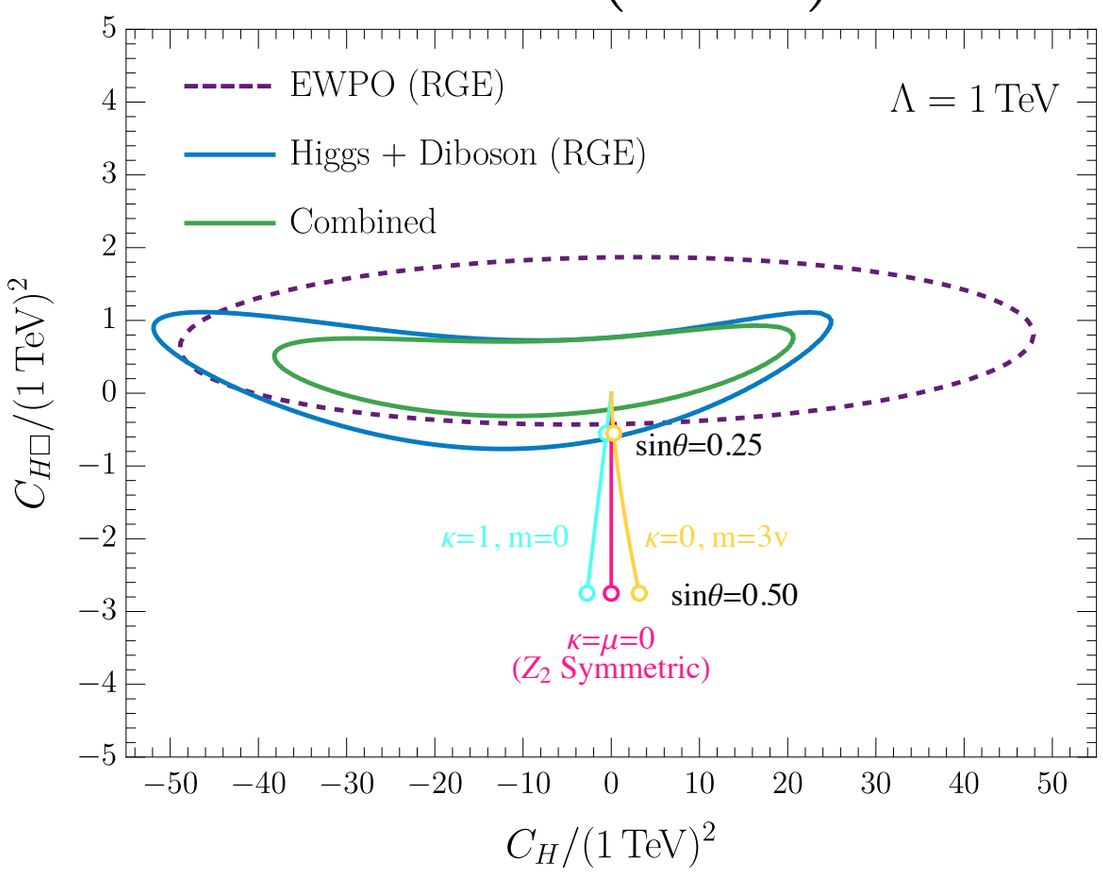
Model described by *two* parameters — mixing angle and mass splitting

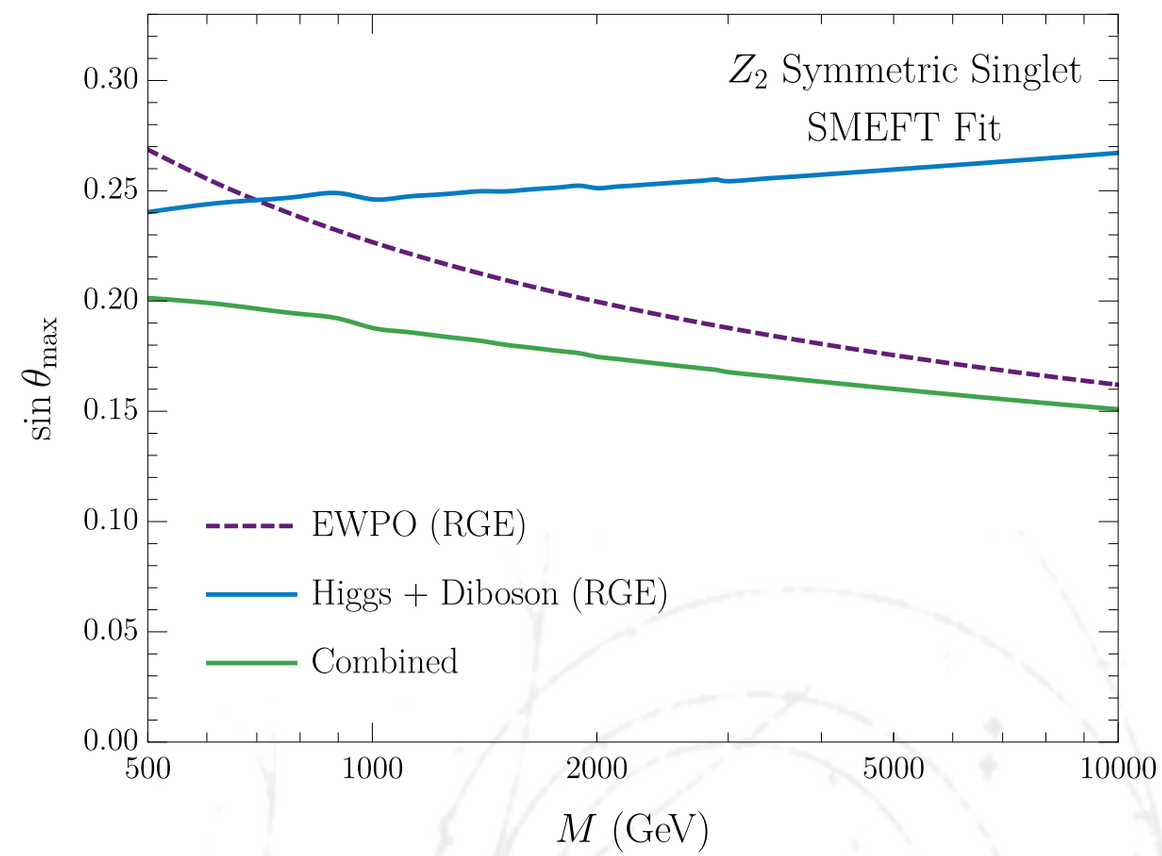


SM + Singlet Scalar

Generates C_H, $C_{H\Box}$ at the matching scale

$$\mathcal{O}_H = \left(H^\dagger H\right)^3$$

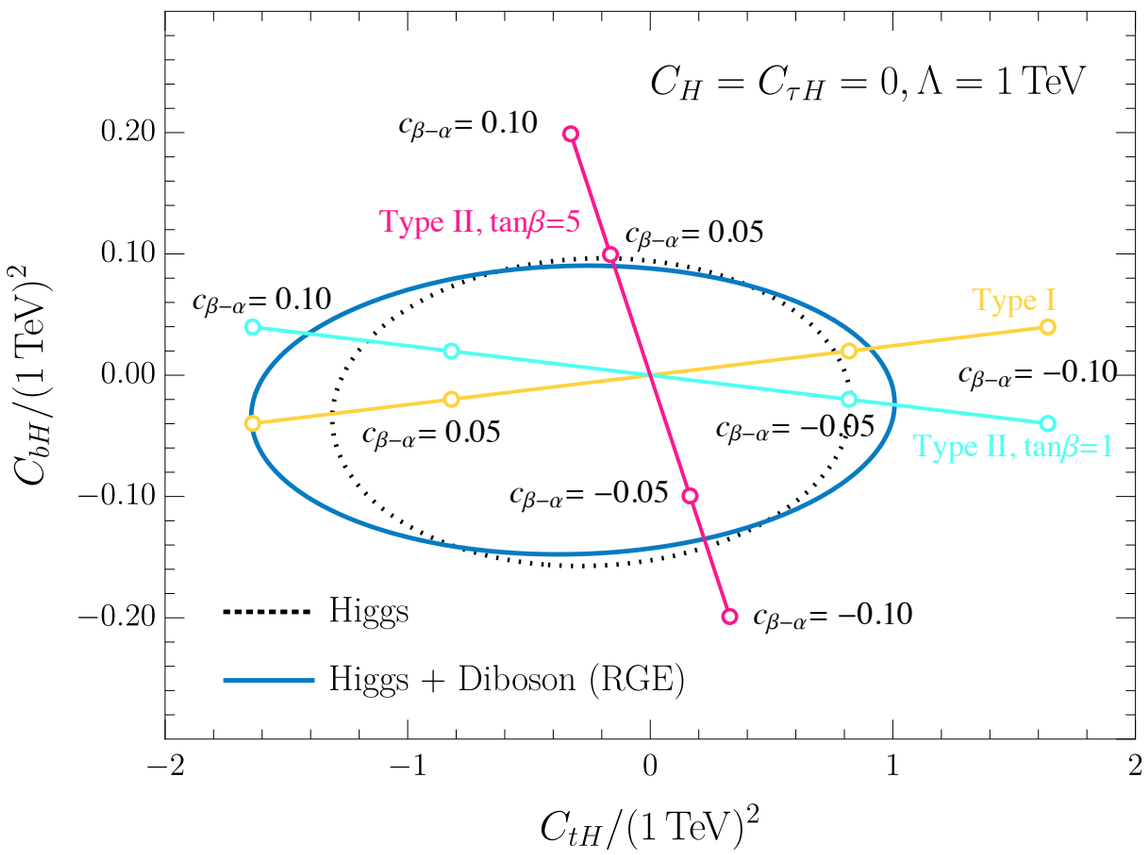


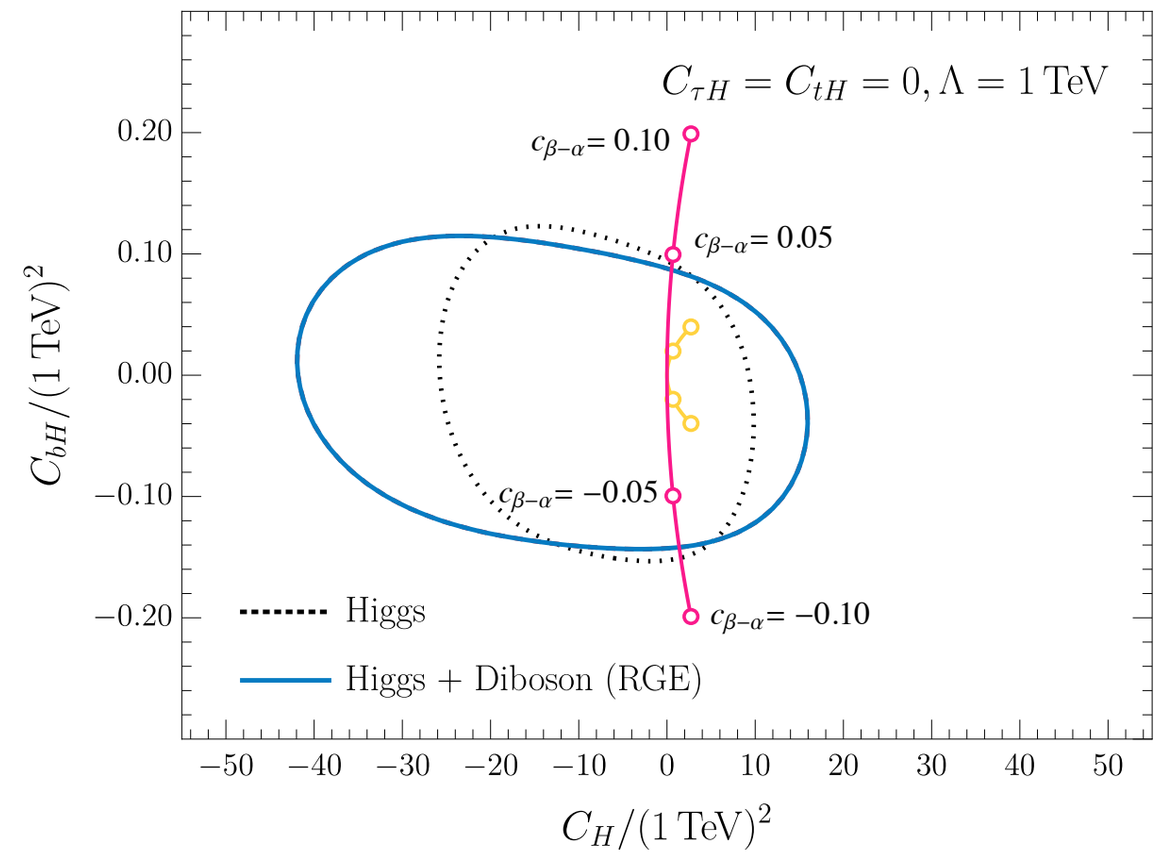


Limits on the singlet from EWPO and LHC competitive — but most allowed coefficients cannot be generated in the model

Two Higgs Doublet Models

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





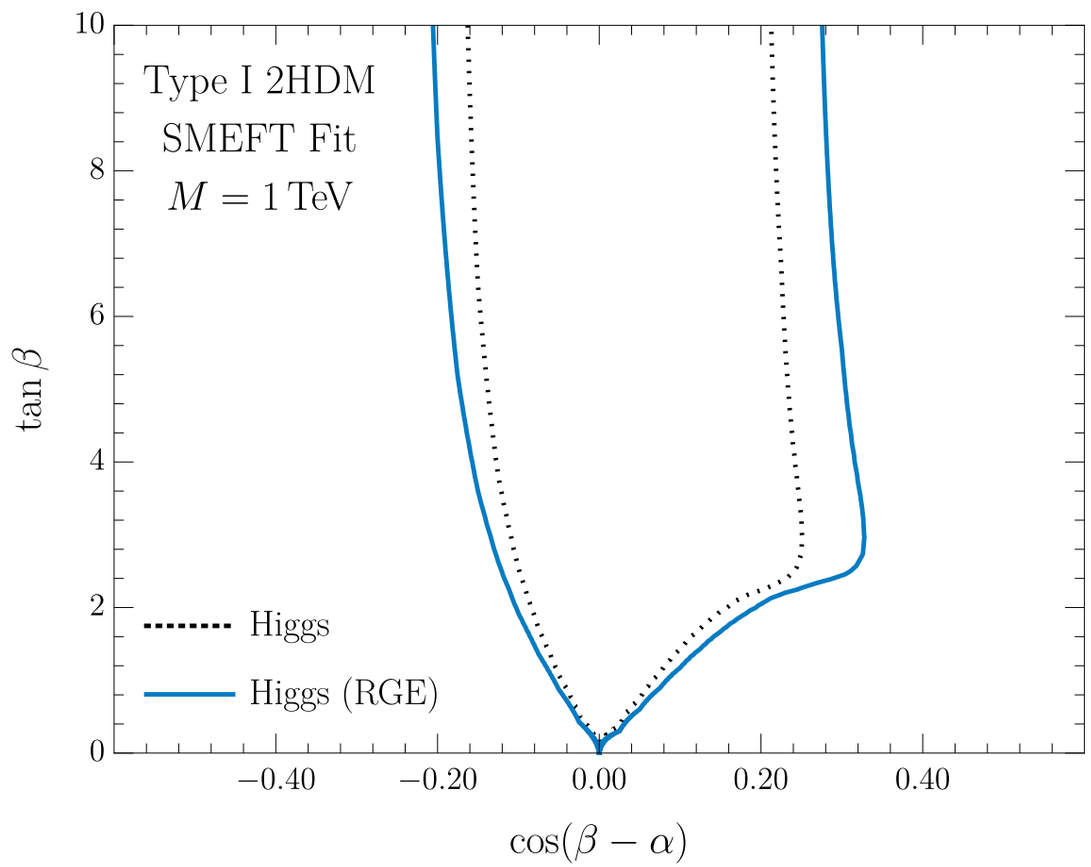
2HDM limits come entirely from Higgs data

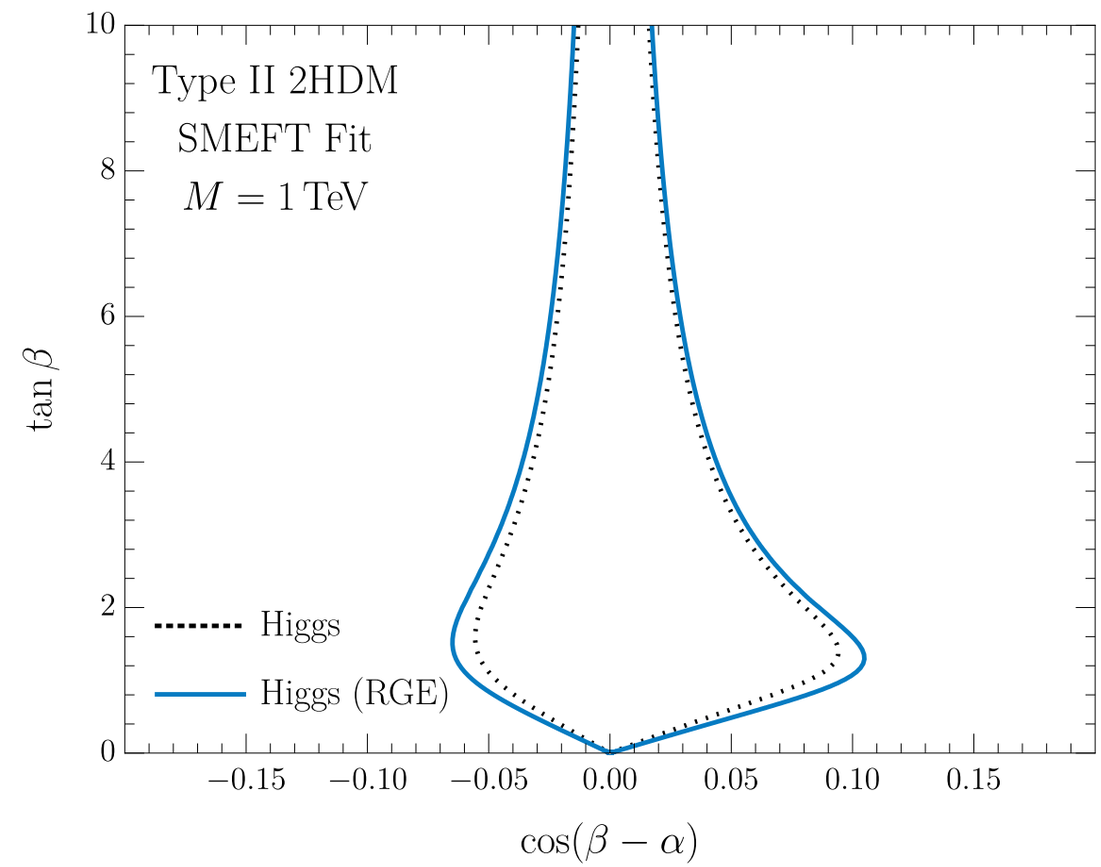
Different types of models sweep out wide range of allowed coefficients

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!

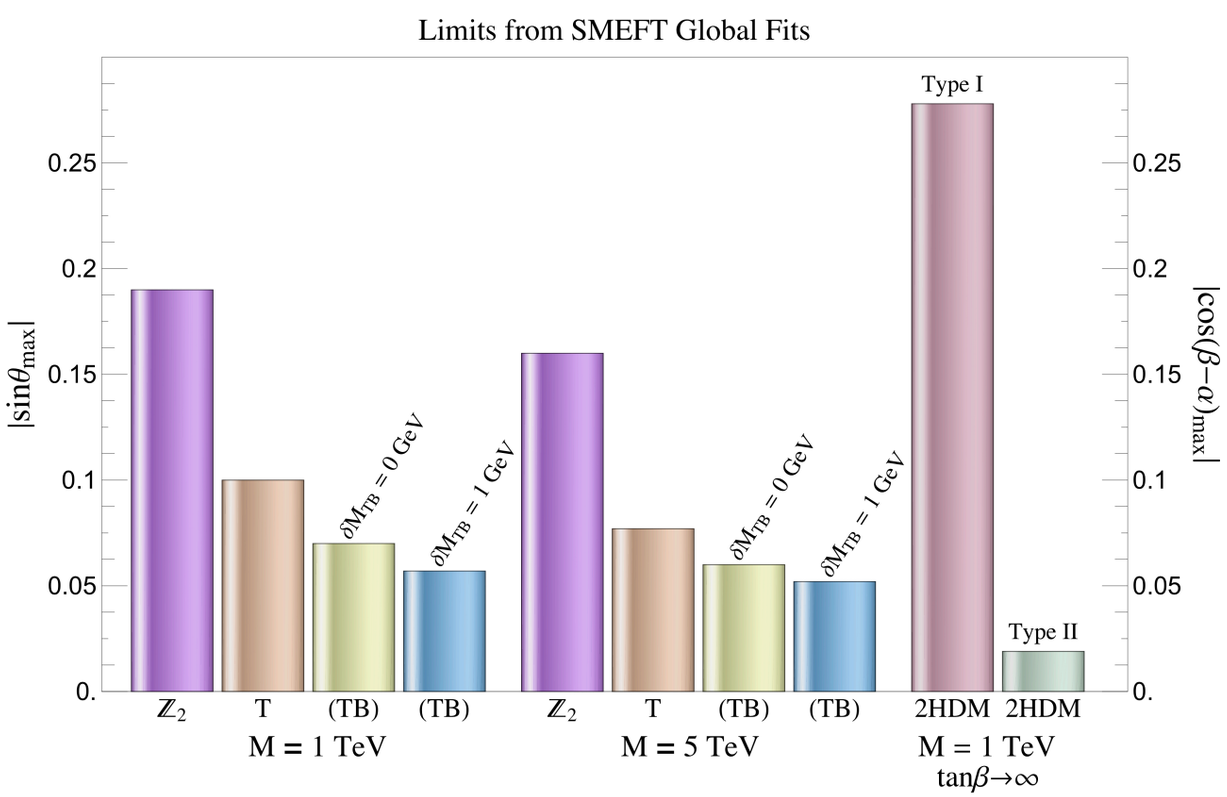




Bounds can be reinterpreted in the usual physical parameter space
RGE effects slightly change the limits

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