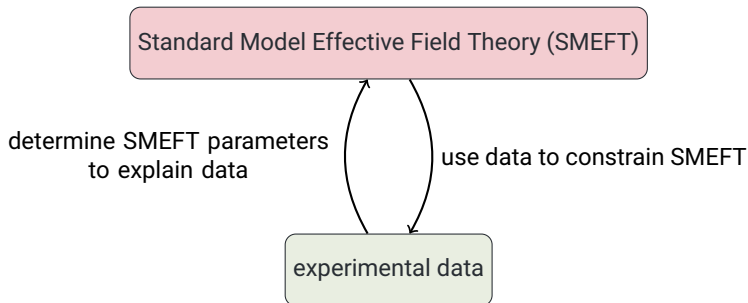


Summary of Area 5 activities and new directions

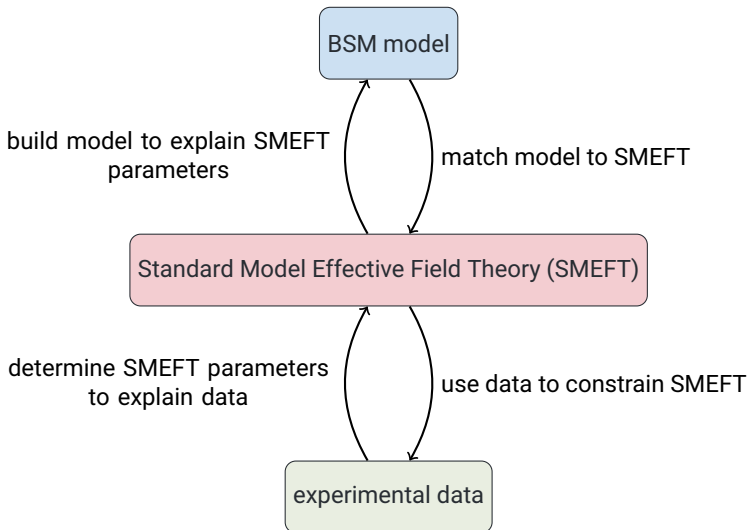
Peter Stangl CERN

LHC EFT Working Group Activity Area 5
Benchmark Scenarios from UV Models

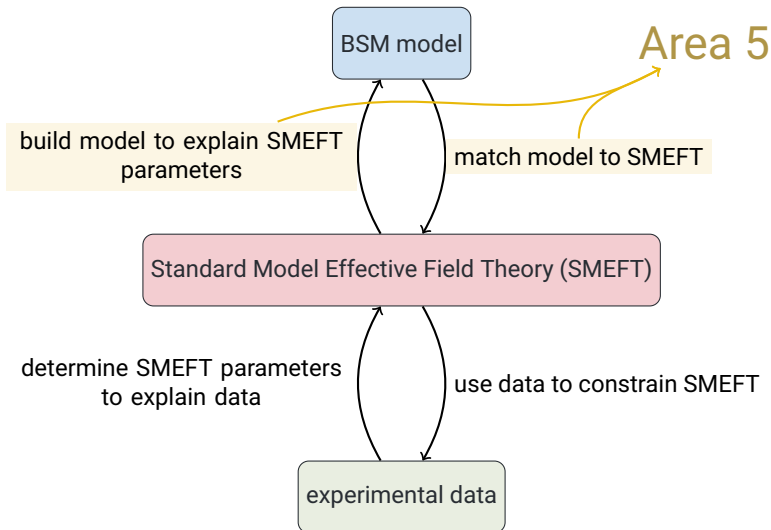
Activity Area 5: Benchmark Scenarios from UV Models



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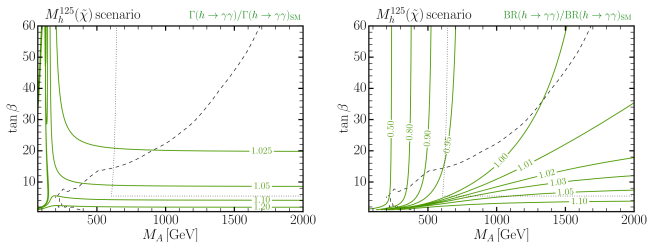


Summary of topical meeting (26 June 2023)

Summary of topical meeting (26 June 2023) indico.cern.ch/event/1294278

- ▶ SMEFT to 2HDM matching within ATLAS by Andrea Visibile
[see talk by Andrea Visibile in this session](#)
- ▶ Matching MSSM onto SMEFT by Emanuele Angelo Bagnaschi
- ▶ Matching 2HDM onto SMEFT and HEFT by Duarte Fontes
- ▶ Matching UV onto SMEFT including D8 operators by Joydeep Chakraborty
[see talk by Joydeep Chakraborty in this session](#)

Possible inter-WG collaborations



[Bagnaschi et al' 18, 1808.07542]

Collaboration with the LHCHWG

- We have seen the importance of the Higgs mass, for the stop/sbottom sector → need fully defined scenarios to have meaningful MSSM results
- What I was thinking is that one work benchmark scenarios as we develop them in the LHCHWG, providing also predictions for the Wilson coefficients of the dimension-6 operators
- Is there interest for this from the experimental community?

Matching 2HDM onto SMEFT and HEFT by Duarte Fontes

Motivation 2HDM Decoupling SMEFT HEFT Results

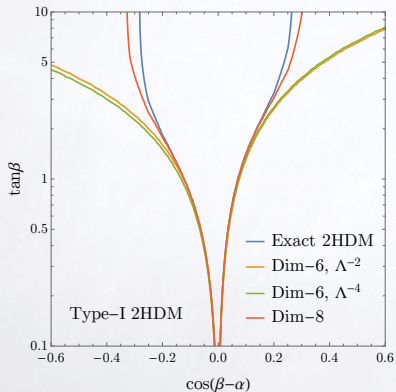
- Higgs signal strengths:

$$\mu_{pp \rightarrow h \rightarrow f}^P = \frac{\sigma^P(pp \rightarrow h)}{\sigma^P(pp \rightarrow h)_{\text{SM}}} \times \frac{\text{BR}(h \rightarrow f)}{\text{BR}(h \rightarrow f)_{\text{SM}}}$$

prod. modes: $ggh, \text{VBF}, Wh, Zh, t\bar{t}h$

final states: $\gamma\gamma, b\bar{b}, \tau^+\tau^-, W^+W^-, ZZ$

- SMEFT fits, assuming $m_H = m_A = m_{H^\pm}$:



- For high $\tan\beta$, the dim-6 results are poorly constrained

- the only WCs are the Yukawa ones, which in Type-I are $\propto 1/\tan\beta$

- The exact 2HDM has **more info** than Yukawas

gauge-Higgs interactions

- But that **info** is contained in the dim-8 results

$$S_{\text{all},8} \ni C_{\mathcal{H}6}^{(1)} (\mathcal{H}^\dagger \mathcal{H})^2 (D_\mu \mathcal{H})^\dagger (D^\mu \mathcal{H})$$

- The dim-8 EFT is thus a **good reproduction** of the exact model – whereas dim-6 is clearly insufficient for some regions

LHC EFT WG Note:
Precision matching of microscopic physics to the
Standard Model Effective Field Theory (SMEFT)

- ▶ Matching Codes

- ▶ CoDEx
- ▶ Matchete (and SuperTracer)
- ▶ MatchMakerEFT
- ▶ MatchingTools
- ▶ STrEAM

- ▶ Codes for RG running in SMEFT and Weak Effective Theory (WET)

- ▶ DsixTools
- ▶ RGESolver
- ▶ wilson

- ▶ Wilson Coefficient exchange format (WCxf)

- ▶ Matching Codes
 - ▶ CoDEx **one-loop matching**
 - ▶ Matchete (and SuperTracer) **one-loop matching**
 - ▶ MatchMakerEFT **one-loop matching**
 - ▶ MatchingTools
 - ▶ STrEAM
- ▶ Codes for RG running in SMEFT and Weak Effective Theory (WET)
 - ▶ DsixTools
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- ▶ CoDEx **one-loop matching**
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- ▶ MatchMakerEFT **one-loop matching**
- ▶ MatchingTools **tree-level matching**
- ▶ STrEAM

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- ▶ STrEAM **supertrace evaluation**

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- ▶ STReAM **supertrace evaluation**

▶ Codes for RG running in SMEFT and Weak Effective Theory (WET)

- ▶ DsixTools SMEFT & WET running, SMEFT \rightarrow WET matching (Mathematica)
- ▶ RGEsolver SMEFT running (C++)
- ▶ wilson SMEFT & WET running, SMEFT \rightarrow WET matching (Python)

▶ Wilson Coefficient exchange format (WCxf)

- ▶ Mathematica package
- ▶ Functional method
- ▶ Source code: <https://github.com/effExTeam/CoDEx-1.0.0>
- ▶ Latest public version: v1.0 (16 Aug. 2018)
- ▶ Missing/Work in progress (only available in non-public developers' version)
 - ▶ Heavy-light contributions
 - ▶ Identities for basis transformations
 - ▶ WCxF support





- ▶ Mathematica package
- ▶ Functional method
- ▶ Source code: <https://gitlab.com/matchete/matchete>
- ▶ Latest public version: v0.1.7 (02 Nov. 2023)
- ▶ Missing/Work in progress
 - ▶ Basis transformations (incl. treatment of evanescent operators)
 - ▶ Integrating out heavy vectors
 - ▶ Computation of β functions

- ▶ Python package (using Mathematica, FeynRules, FORM, QGRAF)
- ▶ Diagrammatic method
- ▶ Source code: <https://gitlab.com/m4103/matchmaker-eft>
- ▶ Latest public version: v1.1.3 (30 May 2023)
- ▶ Missing/Work in progress
 - ▶ Basis transformations
 - ▶ Integrating out of arbitrary heavy vectors



Interfacing matching codes and fitting/likelihood codes

Interfacing matching codes and fitting/likelihood codes

- ▶ **match2fit** github.com/arossia94/match2fit ter Hoeve, Magni, Rojo, Rossia, and Vryonidou, arXiv:2309.04523
see also talk by Alejo Rossia
 - ▶ Interface between **MatchMakerEFT** and **SMEFiT**
 - ▶ **SMEFiT** toolbox for performing **Higgs, EW, Top** fits using specific **SMEFT flavour assumptions** Giani, Magni, Rojo, arXiv:2302.06660
 - ▶ **match2fit** writes **SMEFiT** run cards based on **MatchMakerEFT** matching results
 - ▶ **WIP**: support for **WCxf** (Wilson coefficient exchange format), full one-loop matching support (partial support since v1.8), RG evolution?
- ▶ **smelli** github.com/smelli/smelli Aebischer, Kumar, PS, Straub, arXiv:1810.07698
 - ▶ **SMEFT** likelihood based on **flavio**, **wilson**, and **WCxf**
 - ▶ **flavio** observable calculator for **Flavour, Higgs, EW, Drell-Yan** taking into account **full SMEFT flavour structure** Straub, arXiv:1810.08132
 - ▶ **wilson** performs **RG evolution** in SMEFT and WET Aebischer, Kumar, Straub, arXiv:1804.05033
 - ▶ **WCxf** interface to **MatchMakerEFT** and **Matchete** matching results
 - ▶ **WIP: direct import of matching results** from **MatchMakerEFT** and **Matchete**
→ likelihood function for UV model parameters with arbitrary flavour structure

Area 5 plan: Benchmark UV-EFT Matching Results

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Benchmark UV-EFT Matching Results in a gitlab repository

- ▶ Specific format and contents to be decided see talk by Juan Carlos Criado in this session
 - ▶ Matching results (analytical expressions for given model)
 - ▶ Validation results (numerical matching coefficients for benchmark scenarios)
 - ▶ Additional information (author names, theory assumptions, complete UV Lagrangian, set of benchmark parameter values used for the validation results, etc.)
- ▶ Several benchmark models for different purposes, e.g.
 - ▶ 2HDM probing dim-8 effects cf. Dawson, Fontes, Homiller, Sullivan, arXiv:2205.01561
 - ▶ MSSM for comparison with LHCHWG cf. Bagnaschi et al., arXiv:1804.05033
 - ▶ Scalar leptoquarks already matched at one loop (e.g. quark flavour physics) Gherardi, Marzocca, Venturini, arXiv:2003.12525
 - ▶ Vectorlike quarks already matched at one loop (e.g. first-row CKM unitarity) Crivellin, Kirk, Kitahara, Mescia, arXiv:2212.06862
 - ▶ Models proposed in LHC Higgs WG note Marzocca et al., arXiv:2009.01249