

LHC EFT Working Group efforts

Ilaria Brivio

University and INFN Bologna

on behalf of the LHC EFT WG conveners



ALMA MATER STUDIORUM
UNIVERSITÀ DI BOLOGNA

The LHC EFT Working Group

Website lpcc.web.cern.ch/lhc-eft-wg
Meetings indico.cern.ch/category/12671/
Twiki twiki.cern.ch/twiki/bin/view/LHCPhysics/LHCEFT [[CDS documents](#)]
Contact lhc-eftwg-admin@cern.ch [[sign up](#)]

Conveners

- ATLAS**
 - Sandra Kortner
 - Sarah Heim (Higgs)
 - Jacob Kempster (Top)
 - Kristin Lohwasser (EW)
- CMS**
 - Nadjieh Jafari
 - Nicholas Wardle (Higgs)
 - Robert Schöfbeck (Top)
 - Matteo Presilla (EW)
- LHCb**
 - Greg Ciezarek
 - Christoph Langenbruch
- Theory**
 - Ilaria Brivio
 - Gauthier Durieux
 - Admir Greljo
 - Anke Biekötter (Higgs)
 - Shankha Banerjee (EW)
 - Ken Mimasu (Top)

started in 2020, had a significant conveners turnover in fall 2022.

several new activities planned/started after General Meeting last december

overview of targets:  2020 doc + Twiki

Area 1. EFT Formalism

Ilaria, Gauthier, Matteo

Area 2. Predictions and Tools

Ken, Ilaria, Sarah, Robert

Area 3. Experimental measurements and observables

Anke, Shankha, Jacob, Kristin, Nadjieh

Area 4. Fits and related systematics

Anke, Ken, Kristin, Jacob, Nicholas

Area 5. Benchmark scenarios from UV models

Shankha, Admir, Sandra

Area 6. Interplay with (heavy) flavour

Admir, Gauthier, Greg, Christoph

Past WG activities

- ▶ 2 notes released within **Area 1**

“Electroweak input parameters”

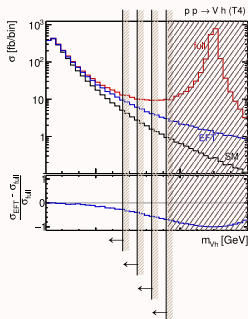
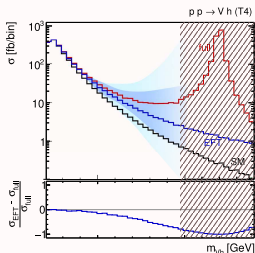
CERN-LHCEFTWG-2021-001
2111.12515

- 👉 recommend $\{m_W, m_Z, G_F\}$ as input parameters for EW sector
- 👉 discuss pros+cons of adopting other options (e.g. $\{\alpha, m_Z, G_F\}$)

“Truncation, validity, uncertainties”

CERN-LHCEFTWG-2021-002
2201.04974

- 👉 collect proposals for ensuring EFT validity and assessing $d \geq 8$ impact e.g. clipping data, clipping prediction, introducing uncertainty band...
- 👉 no recommendation, summarizes meeting discussions
- 👉 will be updated soon with recent proposals, still open to new ones

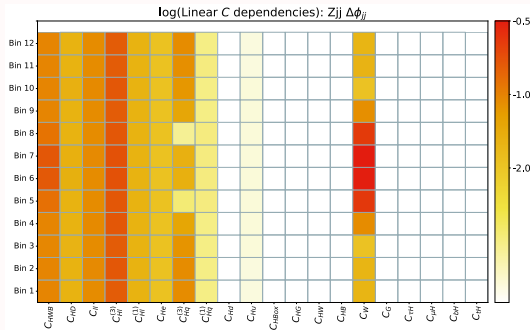


Past WG activities

- ▶ 2 notes released within **Area 1**
- ▶ 1 note released within **Area 3**

“Experimental Measurements and Observables” CERN-LHCEFTWG-2022-001
2211.08353

- 👉 review options for definition of optimal observables
- 👉 report and compare results from theory fits, focusing on who constrains what (Fisher information, comparison of linear and quadratic. . .)



Fitmaker team:
Ellis, Madigan, Mimasu, Sanz, You

Past WG activities

- ▶ 2 notes released within **Area 1**
- ▶ 1 note released within **Area 3**
- ▶ 1 note released within **Area 5**

“Precision matching of microscopic physics to SMEFT”

CERN-LHCEFTWG-2022-002
2212.02905

- 👉 Overview of tools for 1-loop matching of models to SMEFT
matching of SMEFT to LEFT
RGE running



CoDE χ

STrEAM



Past WG activities

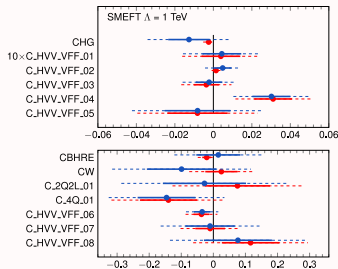
- ▶ 2 notes released within **Area 1**
- ▶ 1 note released within **Area 3**
- ▶ 1 note released within **Area 5**
- ▶ 1 note in progress within **Areas 1+3+6**

“Benchmarks for Flavour assumptions”

- 👉 estimate nr of relevant parameters for well-defined observables sets, varying flavor symmetry assumptions between 5 benchmarks
- 👉 roadmap for future fits and LHC targets

ATLAS + CMS “Fitting exercise” [area 4, ongoing]

- ▶ **main goal:** harmonize workspaces and conventions, iron out differences between ATLAS and CMS, identify potential issues
- ▶ done with **public data**, public combination code [ATLAS repo] [CMS repo]
- ▶ dataset encompasses Higgs + EW + top included so far:
 - LEP + SLC
 - [A+C] STXS $h \rightarrow \gamma\gamma$, $h \rightarrow 4l$, $VH(bb)$
 - [C] single top (p_T^t)
 - diboson: [C] $W\gamma$ ($p_T^\gamma \times \Delta\phi$)
 - [A] WW (p_T^l)
 - [A] WZ (m_T^{WZ})
 - [A] Zjj ($\Delta\phi_{jj}$)
- ▶ statistical combination: RooFit model with multi-variate Gaussian pdf
- ▶ will be used also as **playground for studies of other areas:** truncation benchmarking, using ML observables, matching to models...



Recently started WG activities

Area 2 Database of SMEFT predictions

started by Higgs WG

contact: Ken Mimasu

Area 2 Note on Monte Carlo predictions

contacts: Robert Schöfbeck, Matteo Presilla, Matthew Knight

latest meeting May 24: indico.cern.ch/event/1281726

next meeting June 28: indico.cern.ch/event/1291971

Area 3 Definition of optimal observables with Machine Learning

contact: Jacob Kempster

All Areas Monthly meetings with presentations of recent works

links to meetings in [March](#), [April](#), [May](#), [June](#)

next: July 24 (TBC)

SMEFT predictions database

goal a validated database of SMEFT predictions for “recurring” observables

- ready-to-use, derived **once and for all**
- **shared** between ATLAS and CMS, available to everyone
- **high-quality**: high-statistics simulations, consistent assumptions. . .
- store central values and **uncertainties**: PDF, scale. . .

status

- ▶ **STXS**, fixed flavor and EW inputs.
LO (SMEFTsim) and NLO QCD (SMEFT@NLO)
- ▶ comparisons between ATLAS and CMS ongoing
- ▶ json format being defined

possible future directions

- ▶ develop parsers and search tools, open to community submission
- ▶ **more observables**. eg. EWPO, unfolded diboson/ $t\bar{t}$ distributions
- ▶ numerical predictions derived **(semi)-analytically**, eg. NLO EW

Studies on Monte Carlo predictions

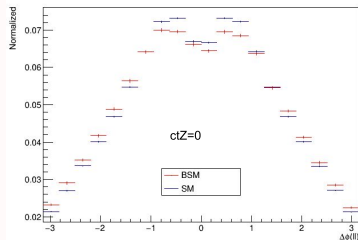
goal

compare and validate different MC techniques for SMEFT simulations, define recommendations and improve existing tools

- **direct** simulation vs **reweighting**
- **helicity-aware** vs **helicity-ignorant** reweighting
- how to interface to MadSpin, parton shower. . .
- explore feasibility of **post-mortem reweighting**

status

- ▶ meeting on May 24:
presentations summarizing studies in ttZ , VH , WZ , VBF-H in ATLAS/CMS with SMEFTsim, SMEFT@NLO, dim δ_{top}
- ▶ a few **discrepancies** identified
- ▶ plans for more in-depth studies separating SM, interference, quadratics



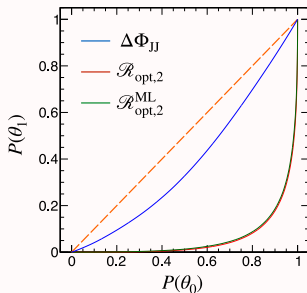
Definition of optimal observables

tasks:

- ▶ **maximize sensitivity**
→ discriminate SM vs EFT, EFT operators among each other
- ▶ ensure **reproducibility** of likelihood ratio outside collaborations
→ by theorists, other experiment, future users . . .

options to evaluate: (*)

- ▶ folded / unfolded
- ▶ binned / unbinned
- ▶ ME or ML-based
- ▶ . . .



(*) putting together the steps of defining observables and measurements (“fitted” quantities)

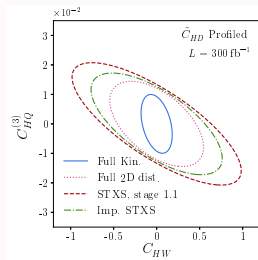
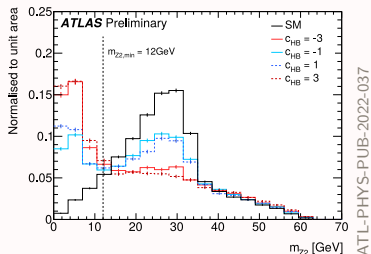
Folded/Unfolded observables

Folded

- ✗ hard to reproduce a posteriori
- ✓ requires weaker modeling assumptions
- ✓ preserves all measurement features

Unfolded

- ✓ easier to reinterpret
- ✗ often assume SM for acceptance, efficiencies, backgrounds...
- ✗ information loss



Brehmer, Dawson, Homiller, Kling,
Plehn 1908.06980

Upcoming meetings

- ▶ **Area 5 meeting** on recent developments on **matching** EFT and UV models
📅 June 26 indico.cern.ch/event/1294278/
- ▶ **Area 1 meeting** on **positivity bounds**
 - collecting & comparing results from theory groups
 - how to account for these constraints in exp analyses📅 July 3 (TBC)
- ▶ **6th General Meeting**
📅 **November 16-17** indico.cern.ch/event/1296757/
format and content still being defined. most likely @CERN + zoom

Potential activities for the future

some topics brought up at past meetings:


- ▶ Studies for $H + HH$ combinations (\rightarrow Higgs WG)
- ▶ **Validation** procedure for NLO event generators
- ▶ Database of **conversions** between tools and notations
- ▶ Preparation of **shared samples** for some measurements
- ▶ Adding **EFT weights to HEPdata** for reco-level observables
- ▶ Start a **full-likelihood combination** in parallel to fitting exercise
- ▶ Database of **1-loop matching** results for UV benchmark models
- ▶ Matching of **MSSM** in decoupling limit
- ▶ ...

new suggestions are always welcome!

participation to the activities is open to anyone!


a newly approved COST Action!


COMETA = “COmprehensive Multiboson Experiment-Theory Action”

 very broad scientific program, includes:

- ▶ **SMEFT/HEFT studies** of multi-boson processes (as many H/W/Z as wished)
- ▶ work towards **multi-boson combined analyses**, also within ATLAS/CMS
- ▶ **W, Z polarizations**: conventions, higher-order predictions, simulations
- ▶ development of **ML-based tools**, together with ML experts outside academia: polarization taggers, jet taggers for VBF topologies, optimal observables. . .

 for networking: will organize **workshops, schools, topical meetings**
+ funds for short/medium-term **visits** to other institutions within Europe

 currently ~ 1/3 theorists + 2/3 experimentalists + a few ML experts

 funding will start in November, activities in 2024 – 2027

sign up & more info at www.cost.eu/actions/CA22130/