Introduction

2nd General Meeting of the LHC EFT WG

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on behalf of the WG conveners

3 May 2021

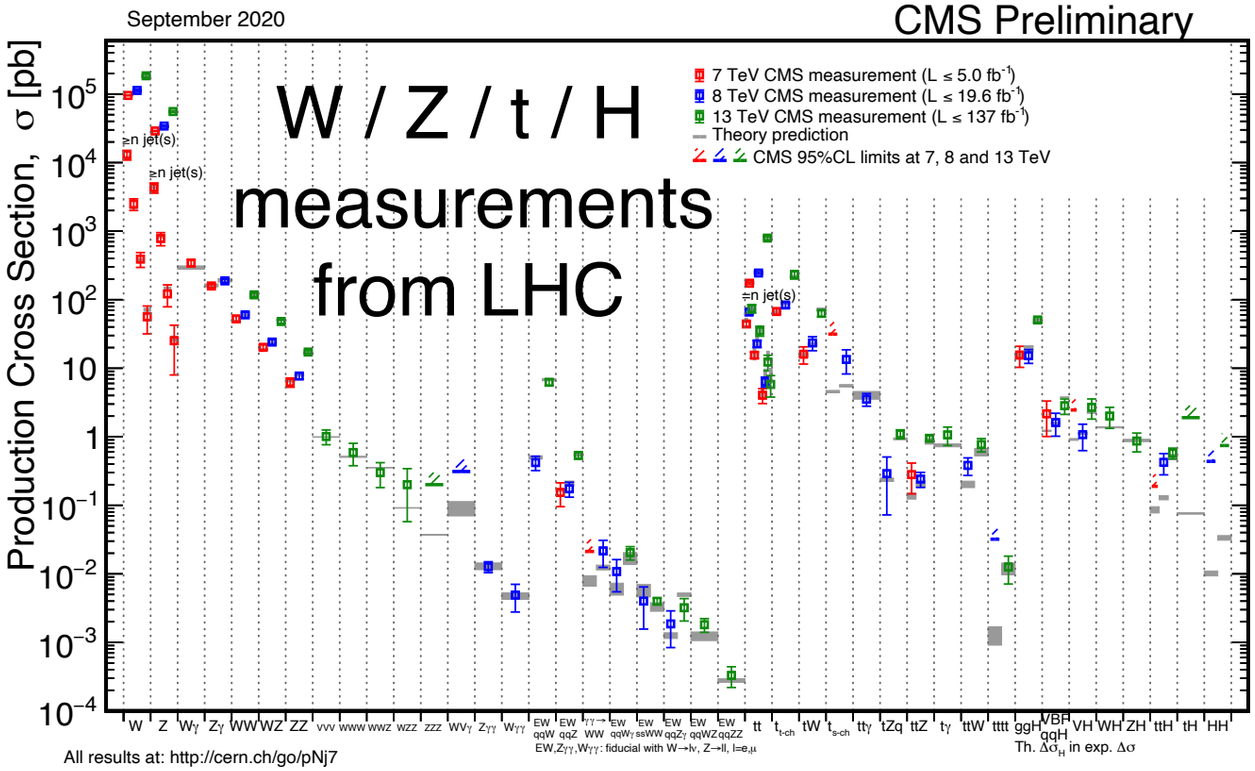
LHC Effective Field Theory Working Group

- Working Group formed in July 2020:

— focus on recommendations, developments, and combinations

— coordination between the existing WGs (Higgs, Top, ElectroWeak)

— global EFT analyses inside and outside experimental collaborations



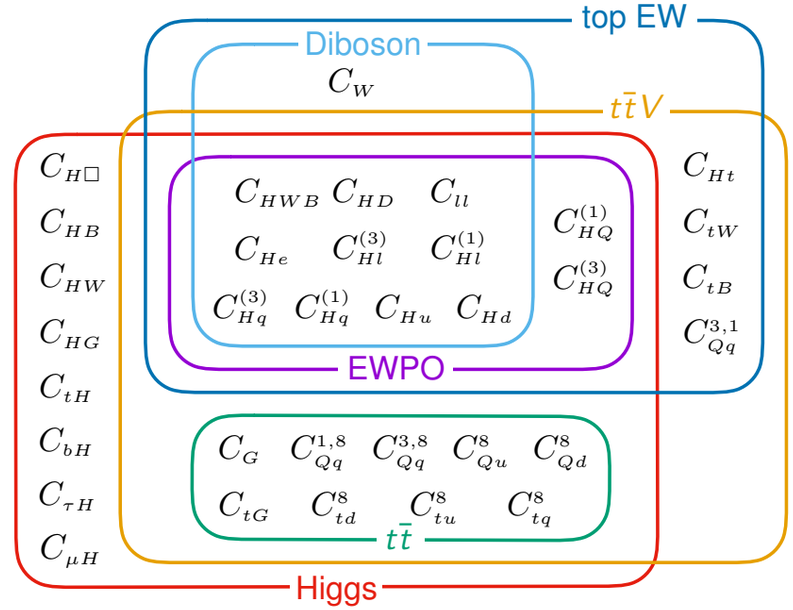


image from Fitmaker team

theory

experiment

July 2020:

LHC Effective Field Theory WG

To subscribe to the general WG mailing list, used to distribute announcements about WG meetings and available documents, go to
http://simba3.web.cern.ch/simba3/SelfSubscription.aspx?groupName=lhc-eftwg

The working group twiki page is available at https://twiki.cern.ch/twiki/bin/view/LHCPhysics/LHCEFT

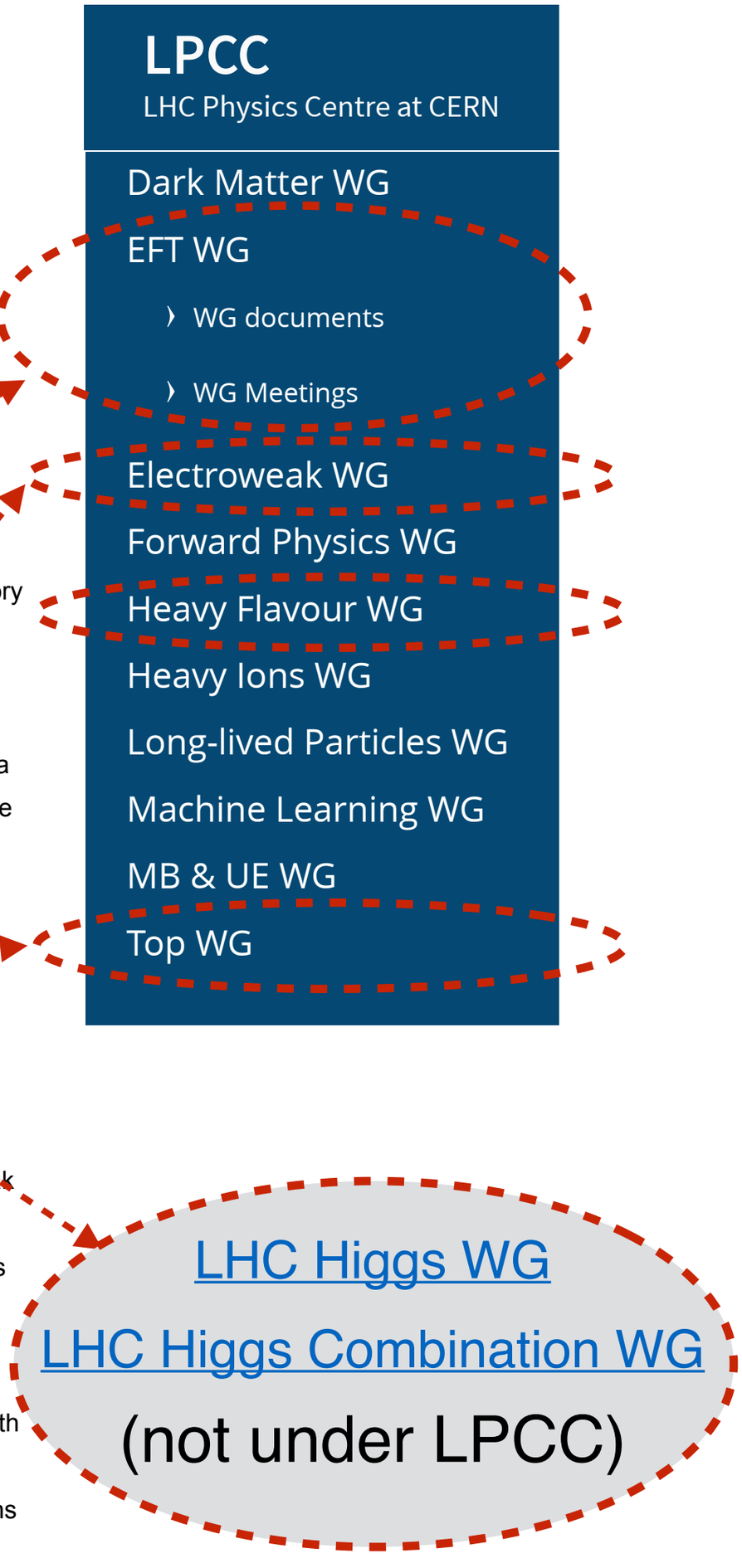
https://lpcc.web.cern.ch/lhc-eft-wg

Mandate:

The LHC effective field theory working group (LHC EFT WG) gathers members of the LHC experiments and the theory community to provide a framework for the interpretation of LHC data in the context of effective field theories (EFTs). The LHC EFT WG studies the physics requirements needed to facilitate an interpretation commensurate with the available measurements performed in a wide range of different processes, including Higgs bosons, top quarks, and electroweak bosons. It provides recommendations for the use of EFT by the experiments to interpret their data, and a forum for theoretical discussions of EFT issues. This includes recommendations on the theory setup as well as Monte Carlo simulation and other tools needed for EFT analyses. Further theoretical issues cover, for example, theoretical constraints, higher-order corrections, BSM interpretations. The LHC EFT WG also discusses common uncertainties and combination procedures used by the experiments. It focuses on recommendations, developments, and combinations that require coordination between the existing WGs (Higgs, Top, Electroweak), in order to allow global EFT analyses inside and outside experimental collaborations. EFT-related activities in these working groups will continue if they pertain only to that group, in close contact with the LHC EFT WG.

The steering group (SG) of the LHC EFT WG consists of experimental and theory conveners. The ATLAS and CMS experiments will each appoint 4 conveners, of which three will be contacts to each of the Higgs, Top, and Electroweak WGs. Up to 8 theorists will also be appointed by the head of LPCC, in consultation with the Higgs, Top and EW WG conveners for the selection of their 3 theory contacts. Contacts from the other LHC experiments can be envisaged as well. The mandate of the conveners is two years, renewable once, and staggering among outgoing/incoming and continuing conveners is encouraged.

The LHC EFT WG operates by holding public meetings where all relevant topics are discussed. Smaller meetings with a specific focus may be scheduled, and subgroups may be formed as deemed necessary by the SG. The subgroups would report on their activities in the plenary meetings. A special case is that of possible combinations or comparisons of experimental data. In this case the meetings will be restricted to members of the relevant experiments.



LHC EFT WG: Targets and Goals

Conveners:

ATLAS:

- Nicolas Berger (Higgs WG contact)
- Nuno Castro (Top WG contact)
- Kristin Lohwasser (EW WG contact)
- Pierre Savard

CMS:

- Florencia Canelli (Top WG contact)
- Pietro Govoni (EW WG contact)
- Andrei Gritsan
- Giovanni Petrucciani (Higgs WG contact)

LHCb:

- Patrick Owen

Theory:

- Ilaria Brivio
- Sally Dawson
- Jorge De Blas (Higgs WG contact)
- Celine Degrande (EW WG contact)
- Gauthier Durieux
- Admir Greljo
- Eleni Vryonidou (Top WG contact)

Defined targets and goals in summer 2020 (see backup)

with five areas of activity:

https://twiki.cern.ch/twiki/bin/view/LHCPhysics/LHCEFT

Area 1: EFT Formalism

Area 2: Predictions and Tools

Area 3: Experimental Measurements and Observables

Area 4: Fits and Related Systematics

Area 5: Benchmark Scenarios from UV Models

+ Flavor Physics

LHC EFT WG activities in the past 6 months:

https://indico.cern.ch/category/12671/

Today (2nd General meeting)

write-ups (evolving)

dedicated meetings
(~ 6 months)

1st General meeting of the WG

group formed, targets formulated

Idea of the WG floated (~1y ago)

1y

time

0

May 2021

- 03 May 2nd General Meeting of the LHC EFT Working Group

April 2021

- 12 Apr Heavy flavour aspects in EFT fits

February 2021

- 22 Feb Areas 3&4 meeting: experimental measurements, fits and related systematics
- 08 Feb Area 5 meeting: Benchmark scenarios from UV models

January 2021

- 27 Jan Area 4 meeting: fits and related systematics
- 19 Jan Area 1, EFT formalism: follow-up meeting
- 11 Jan Area 3 meeting: experimental measurements and observables

December 2020

- 14 Dec Area 2 meeting: predictions and tools
- 07 Dec Area 1 meeting: EFT formalism

October 2020

- 19 Oct - 20 Oct 1st General Meeting of the LHC EFT Working Group

April 2020

- 17 Apr LHC EFT Working Group: preliminary open discussion

Today's agenda

14:00 → 14:05 **Introduction**

14:10 → 14:30 **Recent EFT measurements from ATLAS and CMS (invited talk)**
Speaker: Jack MacDonald (University of Sheffield (GB))

14:35 → 14:50 **Report on Benchmark scenarios from UV models and Flavor Physics**

14:55 → 15:05 **Report on predictions and tools**

15:10 → 15:25 **Report on EFT formalism**

15:30 → 15:40 **Discussion**

15:40 → 16:00 **Coffee break**

16:00 → 16:20 **Perspectives of Effective Field Theories (invited talk)**
Speaker: Nathaniel Craig (UC Santa Barbara)

16:25 → 16:35 **Report on experimental measurements and observables**

16:40 → 16:50 **Report on fits and related systematics**

17:00 → 17:10 **Fitting exercise: Introduction**

17:15 → 17:30 **Fitting exercise: ATLAS vision**

17:30 → 17:45 **Fitting exercise: CMS vision**

17:45 → 18:00 **Fitting exercise: Discussion**

two invited talks
(experiment & theory)

five reports from Areas 1-5
- status
- activity
- plans
- write-ups (evolving)
- google docs for comments
- discussion

discussion of the fitting exercise
(scope and timeline to be defined)

Plan for this **General** meeting

WG focus: on recommendations, developments, and combinations

We would like to engage WG members (all of you):

- Write-ups (see drafts and google docs attached to the agenda):
  - developments and options (when multiple present) in Areas 1-5
  - recommendations for the best options, when possible
  - requirements and best practice for EFT applications

- Technical fitting exercise (no data yet):
  - options of inside and outside experimental collaborations
  - focus on vision from ATLAS and CMS today
  - input from the theory community is critical

BACKUP

LHC Effective Field Theory Working Group

Area 1: EFT Formalism

This activity area is the starting point for calculations and fits: what operators, what bases, what perturbation orders, how to combine operators of different dimensions, what constraints to be put in the EFT bases preparation, practical considerations in connection to experimental analyses, flavour and symmetry assumptions. The following issues will be discussed:

- SMEFT bases/notation/normalization/input schemes, etc (*): common conventions, consistency checks among the experiments and streamlining translations among conventions will be required, before any combination is considered. These will be defined on a case by case basis, depending on the specific set of observables included in a given combination.
- Assumptions about the flavour symmetries, and other symmetries like CP
- Definition of scenarios, also for the purposes of doing fit with limited data, and as benchmarks for the presentation of experimental results
- Truncation, quadratic dependences, double insertions, dimension eight contributions, uncertainty prescription, EFT validity (information required from experiments to ensure validity at the interpretation stage) (**)
- TH constraints (unitarity, positivity, etc.) and incorporation into fit results (**)
- Consideration of beyond-SMEFT EFT frameworks, where relevant

Area 2: Predictions and Tools

This activity area addresses all issues of how to simulate EFT and generate events; understanding of the limitations of the models and agreements on the way to proceed in the EFT publications and calculations. Identification and estimation of all relevant theory systematics, and calculation in a form which is usable in likelihood fits by the experimental community; investigation of matters related to the computational limitations in the events production for experimental analyses.

- Guidance
  - Availability (analytic & numeric), usage, assumptions, uncertainties, interplay of tools
  - Reweighting techniques to reduce the full detector simulation sample size (and validation of those techniques)
  - Higher-order corrections in SM couplings
- Deliverables
  - Cross-validation at tree and loop levels
  - Common MC generation and/or settings across experiments
  - Observable calculations (including e.g. fiducial cross-sections, see Area 3.) and analytical parameterizations (also to NLO), comparisons between tools, uncertainties
  - Tools to relate parameters, measured quantities, etc
- Specific theory developments
  - Recommendations for the treatment of unstable particles (combining EFT dependence in production, total width, and decay; treatment in MC tools) (**)
- EFT in PDFs, alpha_s, shower and hadronization

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Area 3: Experimental Measurements and Observables

This activity area covers how observables relate to operators, which measurements are important for a given operator or set of operators, differential/fiducial measurements vs. dedicated ones, identification of optimal observables, machine learning, re-interpretation vs. static, presentation of results: covariance, multi-D likelihood, etc., compatibility with global fits (i.e. assumptions used in deriving measurement and reporting results).

- Study observable, channel, process sensitivities and complementarities
  - Experimental targets: survey of the sensitive channels and corresponding operators
  - Differential distributions, optimal observables, including machine learning, and dedicated EFT measurements, spin density matrices, EFT-optimized fiducial regions, amplitude analyses, angular distributions (e.g. for CP), pseudo observables, etc.
  - Agreement across experiments (for fiducial regions in particular)
  - What observables are most sensitive to new physics? Exploit energy growing effects, non-interferences, and other TH knowledge
  - Expected uncertainties: sys. or stat. dominated
- Analysis strategies & experimental outputs, also with a view at legacy measurements and their possible reinterpretation
  - Dedicated EFT extractions by collaborations
  - Differential measurements and the best choice of observables for re-interpretation.
  - Presentation of measurements: cross sections, correlations/covariance, multi-D likelihood, etc…
  - Experimental systematics related to EFT (e.g. accounting for detector effects)
  - Detector effects: unfolding, forward folding, efficiency maps, recasting through reweighting, etc.
  - EFT in backgrounds: final-state driven instead of sig-bgd, statistical model

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Area 4: Fits and Related Systematics

This activity area covers issues which are either generic, i.e. they don't depend on specific final states, or that concern the interpretation, preparation and performance of global fits of ATLAS, CMS, LHCb results, together with additional existing measurements, future projections, experimental systematics related to EFT.

- Experimental EFT fits: ATLAS+CMS+... combination of H+EW+Top
- Inputs and outputs, fitting procedures and tools
    - Practical considerations of limited time and experimental input
    - Fitting benchmarks for synchronisation
    - Comparisons of input information between experimental results
    - Compare fits: experimental/theory, among different groups
    - Consideration of common WG fit, framework and/or approaches
- Comparison to, and inclusion of, non-LHC constraints (LEP, Tevatron, flavor, g-2, EDM, etc.) in fits and/or to set priorities among targeted measurements/operators and in sensitivity optimization
- Theoretical systematics, and their correlations (see Area 2.)
- Experimental systematics, and their correlations (see Area 3.)
- Presentation of EFT Fits: multi-D likelihoods, covariance, flat directions, etc…
- Projections of EFT fit constraining power

Area 5: Benchmark Scenarios from UV Models

This activity area is focused on the determination of expected numerical EFT effects from models and constraints on models from expected or obtained EFT fits.

- Matching to specific models, BSM-driven subsets of operators, benchmarks beyond SMEFT, incl. non-linear EFT
- Comparison of EFT constraints vs. direct BSM searches beyond EFT