UNIVERSITÄT BERN

SWISS NATIONAL SCIENCE FOUNDATION
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Open questions from the LHC EFT WG

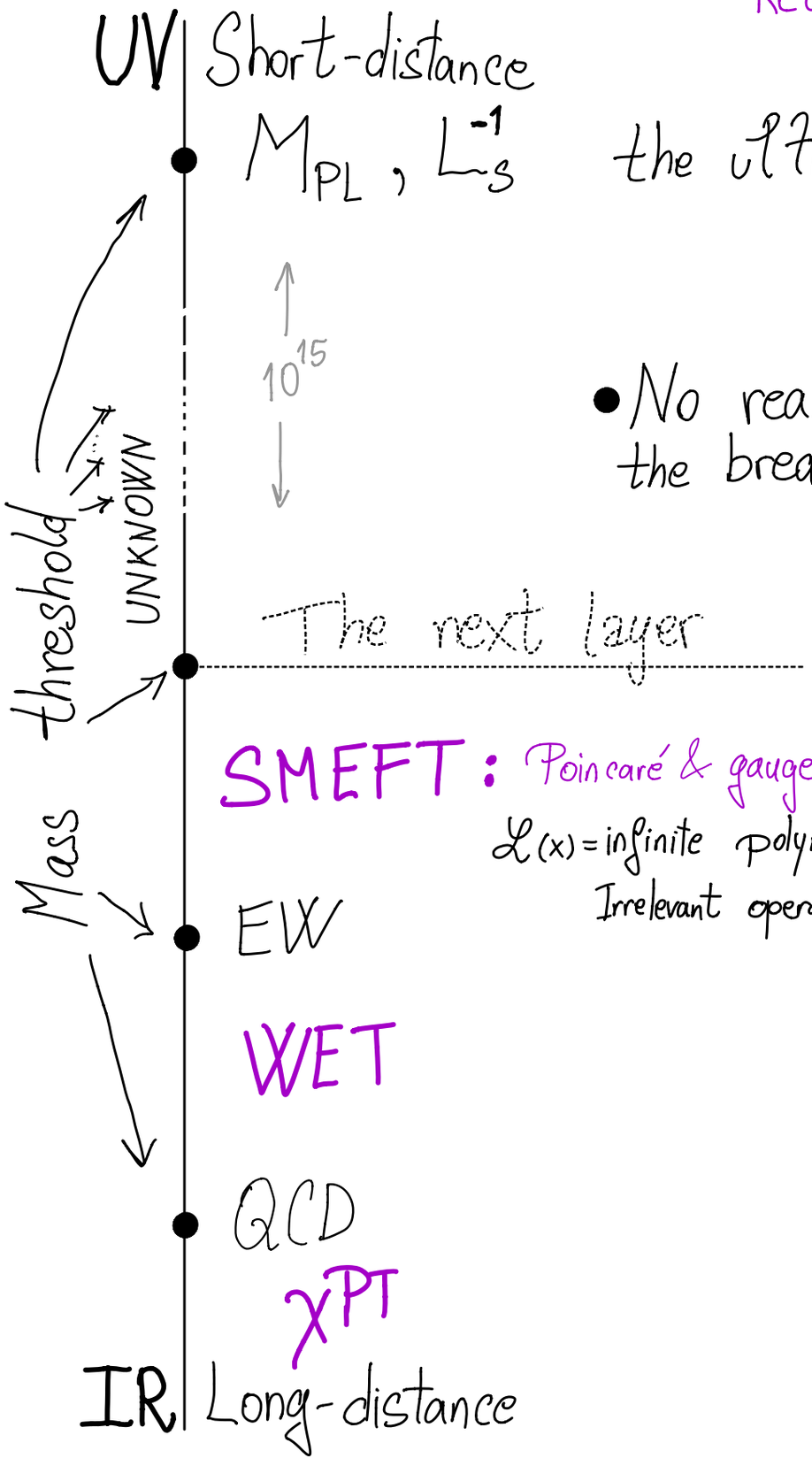
Admir Greljo

- The ongoing and near-future activities of the EFT WG.
- The main open questions relevant for the application of the EFT formalism in the context of LHC analyses.

09.06.2021, LHCP 2021

Wilsonian QFT = the HEP paradigm

Reductionism



- No reason to expect the breakdown anytime soon

EFT @ LHC

- Multitude of processes in the Higgs/Top/EW/Jets/Flavor. Ever-increasing statistics.
- Large number of operators.
- A community effort needed!

LHC EFT WG - intro

- It is a part of the LHC Physics Centre at CERN.
- It gathers members of the LHC experiments and the theory community.
- Provides a framework for the interpretation of LHC data in the context of effective field theories.
- The steering group (SG) of the LHC EFT WG consists of experimental and theory conveners.

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- 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)

- More information

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

Reach all conveners through lhc-eftwg-admin at cern.ch

Subscribe to the general WG mailing list

LHC EFT WG - structure

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

Area 6: Flavour

LHC EFT WG - open meetings

May 2021

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

April 2021

- 12 Apr Area 6 meeting: 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

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

Area 1: EFT Formalism

- The kick-off meetings:
  https://indico.cern.ch/event/971722/
  https://indico.cern.ch/event/980681/

a. Bases, notations, inputs***
   common conventions, translations, common EW inputs

b. Assumptions***
   flavour structures, classes of BSM, symmetries

c. Truncation, uncertainties, validity**
   linear/quadratic, double ins., dim-8, trunc. errors, etc.

d. Theory constraints**
   unitarity, positivity, incorporation in fits

- Area 1 note: In preparation

Community input welcome!

- Area 1 note: In preparation

See talk by Gauthier Durieux, 2nd General meeting

Area 2: Predictions and Tools

- The kick-off meeting: https://indico.cern.ch/event/971724/

- SMEFTSim
- SMEFT@NLO
- MadGraph5_aMC@NLO
- Sherpa
- JHUGen
- Powheg
- VBF@NLO

From an operator to the detector level,
Need for fast and efficient tools:

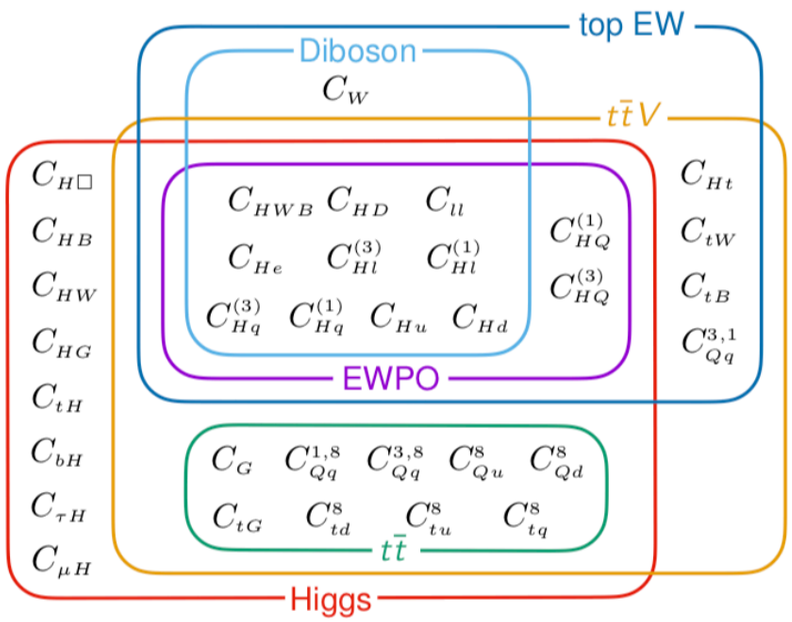
- Guidance
  - Availability (analytic & numeric), usage, assumptions, uncertainties, interplay of tools
  - Reweighting techniques to reduce the full detector simulation sample size (and validation of those techniques)
  - Higher-order corrections in SM couplings
- Deliverables
  - Cross-validation at 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

- Area 2 note: In preparation
  Community input welcome!

See talk by Celine Degrande, 2nd General meeting

Area 3: Experimental Measurements and Observables

- The kick-off meeting: https://indico.cern.ch/event/971725/



- Area 3 note: In preparation

  Community input welcome!

- 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

See talk by Eleni Vryonidou, 2nd General meeting

Area 4: Fits and Related Systematics

- The kick-off meeting: https://indico.cern.ch/event/971727/
- Joint meeting with Area 3: https://indico.cern.ch/event/1007581/

- **Current Area 4 meetings focused on:**
  - ✓ Fitting tools, their validation and interplay with EXP inputs
  - ✓ Reviewing the status of the fitting experience by ATLAS and CMS
  - ✓ Paving the way towards a general & realistic ATLAS/CMS combined EFT fit

- **Several work items identified:**
  - ✓ Definition of fit benchmark scenarios for cross-checking fitting tools
  - ✓ Recommendation for a common output format for fitting tools?
  - ✓ Work with ATLAS and CMS in defining a robust procedure for EFT combinations, using the recommendations of the LHC EFT WG

⇒ LHC global fit combination exercise (see **2nd General meeting**)

Area 4 note:
In preparation

Community input welcome!

EFT*fitter* Fitmaker HEPfit SFitter SMEFiT

See talk by Jorge de Blas, 2nd General meeting

Area 5: Benchmark scenarios from UV models

- The kick-off meeting: https://indico.cern.ch/event/971736/
- How do we best interpret EFT analysis in explicit models?
- A UV model predicts WCs in terms of its parameters. This implies *patterns* in the WCs that serve for model discrimination.
- The key experimental task is to identify these patterns performing dedicated fits.
- The key theoretical aspect is matching the UV model onto EFT at high accuracy. Automated one-loop matching tools.
- Area 5 goal is to set benchmark scenarios:
  1. Interesting phenomenology.
  2. Validation of different tools.

- Area 5 note: In preparation
  Community input welcome!

See talk by AG, 2nd General meeting

Area 6: Flavour

- The kick-off meeting: https://indico.cern.ch/event/1011800/
- Most of the 2499 dim-6 operators in SMEFT are flavourful.
- Flavor physics reaches into most dimensions. It is a key to a global fit.
- Flavor constraints important even for a restricted set of usual universal operators in top/H/EW.
- Tools and theoretical development on SMEFT, WET, RGE & matching?
- What is the LHCb input to the global SMEFT fits?
- How does LHCb handle EFT analysis?

- Area 6 note: In preparation
  Community input welcome!

See talk by AG, 2nd General meeting