Higgs and Effective Field Theory - HEFT 2022

Report of Contributions

https://indico.cern.ch/e/1161919

Contribution ID: **1** Type: **not specified**

Introduction

Wednesday 15 June 2022 09:30 (15 minutes)

Contribution ID: **2** Type: **not specified**

TBD: Review talk

Presenter: SPANNOWSKY, Michael (University of Durham (GB))

Contribution ID: **3** Type: **not specified**

The hunt for non-resonant signals of new physics at the LHC

Wednesday 15 June 2022 09:45 (45 minutes)

10 years after the discovery of the Higgs boson, the LHC is gearing up for two more decades of operations, during which it will evolve into a precision machine. Amidst a shortage of particle discoveries, precision will allow the implementation of new strategies to search for new physics, aiming for non-resonant signals.
This is the main motivation underlying the huge development in EFT methods that we have seen in the past decade. The SMEFT is now established as the preferred framework for the interpretation of non-resonant searches, but the implementation of a global campaign of SMEFT measurements is still in the early phases and presents a number of unsolved aspects. At the same time, alternative EFTs are being studied in the same context, including HEFT but also EFTs with new light degrees of freedom, such as axion-like particles.
The talk will give a broad overview of recent developments in the quest for non-resonant new physics signals and discuss the main challenges that will need to be addressed in the (near) future.

Presenter: BRIVIO, Ilaria (Universidad Autonoma de Madrid (ES))

Contribution ID: **4** Type: **not specified**

Machine-enhanced CP-asymmetries in the Higgs sector

Wednesday 15 June 2022 11:30 (30 minutes)

Improving the sensitivity to CP-violation in the Higgs sector is one of the pillars of the precision Higgs programme at the Large Hadron Collider. I will present a simple method that allows CP-sensitive observables to be directly constructed from the output of neural networks. In this talk, I will show that these observables have improved sensitivity to CP-violating effects in the production and decay of the Higgs boson when compared to the use of traditional angular observables alone. The kinematic correlations identified by the neural networks can be used to design new analyses based on angular observables, with a similar improvement in sensitivity.

Presenter: BHARDWAJ, AKANKSHA (Physical Research Laboratory)

Contribution ID: **5** Type: **not specified**

Quantifying symmetry breaking with flavor-invariants: CP and Peccei-Quinn

Wednesday 15 June 2022 12:30 (30 minutes)

Presenter: BONNEFOY, Quentin (DESY)

Contribution ID: **6** Type: **not specified**

Gearing up for the next generation of LFV experiments, via on-shell methods

Wednesday 15 June 2022 17:30 (30 minutes)

Lepton Flavor Violating (LFV) observables such as $\mu \to e\gamma$, $\mu \to 3e$ and $\mu N \to eN$ are among the best probes for new physics at the TeV scale. In the near future the bounds on these observables will improve by many orders of magnitude. In this work we use the SM EFT to understand the impact of these measurements. The precision reach on the measurement of these processes is such that the interpretation of the bounds requires an analysis of the dimension-six operator mixing up to the two-loop level. Using on-shell amplitude techniques, which make transparent many selection rules, we classify and calculate the different operator mixing chains. At the leading order, on-shell techniques allow to calculate anomalous dimensions of SM EFT operators from the product of tree-level amplitudes, even for two-loop renormalization group mixings. We illustrate the importance of our EFT approach in models with extra vector-like fermions.

Presenter: FERNANDEZ CASTAÑER, Clara (IFAE)

Contribution ID: **7** Type: **not specified**

Rambling about 1/Lambdaˆ4

Friday 17 June 2022 12:45 (45 minutes)

Presenter: CORBETT, Tyler (Niels Bohr Institute)

Contribution ID: **8** Type: **not specified**

Running from the ALPs in SMEFT

Wednesday 15 June 2022 10:30 (30 minutes)

Presenter: RENNER, Sophie Alice (University of Glasgow (GB))

Contribution ID: **9** Type: **not specified**

Electroweak skyrmions in the HEFT (Joint talk with All Things EFT)

Wednesday 15 June 2022 16:00 (1 hour)

Presenter: CRIADO ÁLAMO, Juan Carlos (University of Granada)

Contribution ID: **10** Type: **not specified**

VBS measurements at CMS and constraints on SMEFT operators

Wednesday 15 June 2022 15:00 (30 minutes)

Vector-boson scattering (VBS) processes probe the non-Abelian gauge structure of the electroweak sector of the Standard Model, and provide a unique sensitivity to potential kinematic anomalies arising from the inclusion of SMEFT operators. In this talk, we report on the most recent VBS measurements performed at CMS with the full LHC Run 2 data, and on the corresponding constraints on the relevant dimension 8 SMEFT operators. In addition, we present a sensitivity study on the constraining power of several VBS analyses to anomalous effects arising from dimension-6 SMEFT operators and discuss the prospects of this measurement at the upcoming LHC runs.

Presenter: VAGNERINI, Antonio (Università di Torino)

Contribution ID: **11** Type: **not specified**

EFT in top-quark sector from CMS experiment

Friday 17 June 2022 10:00 (30 minutes)

Presenter: DOBUR, Didar (Ghent University (BE))

Contribution ID: **12** Type: **not specified**

Parton Distributions in the SMEFT from high-energy Drell-Yan tails

Thursday 16 June 2022 17:30 (30 minutes)

The high-energy tails of Drell-Yan processes provide important constraints on the light quark and anti-quark parton distribution functions (PDFs) in the large-x region. On the other hand, hypothetical high-mass new physics could smoothly distort the high-energy tails as described by the Standard Model Effective Field Theory (SMEFT). In this work, we assess for the first time the interplay between PDF and SMEFT effects in high-mass Drell-Yan at the LHC by performing a consistent joint determination of the PDFs and SMEFT Wilson coefficients. I will discuss the extent to which EFT signals which manifest in the tails of Drell-Yan distributions could be reabsorbed into the PDFs, and quantify the impact that a simultaneous fit of the PDFs and Wilson coefficients has on the SMEFT constraints in motivated new physics scenarios. Finally, I will present dedicated projections for the High-Luminosity LHC and evaluate its ultimate potential to constrain the SMEFT parameters while taking into account potential modifications of the PDFs.

Presenter: MADIGAN, Maeve

Contribution ID: **15** Type: **not specified**

SMEFT at higher orders through geometry

Friday 17 June 2022 10:30 (30 minutes)

Presenter: HELSET, Andreas (Caltech)

Contribution ID: **16** Type: **not specified**

Towards Automatic Matching with Functional Methods

Thursday 16 June 2022 10:30 (30 minutes)

Presenter: THOMSEN, Anders Eller (Universität Bern)

Contribution ID: **17** Type: **not specified**

Automatic generation of EFT operators

Thursday 16 June 2022 09:00 (30 minutes)

Effective field theories (EFTs) are a powerful tool for the exploration of potential new physics in a model-independent way. At a time when there is a lack of clarity on how to extend the Standard Model, the Standard Model effective field theory (SMEFT) and related EFTs have been receiving an increasing amount of attention. For example, the number of SMEFT operators, up to high mass dimensions, has been counted with several techniques in the last few years. Building an explicit basis of operators is more complicated, but here too there has been notable progress. In this talk, I will go through my recent work on using the software packages GroupMath and Sym2Int to automatically build explicit bases of operators for EFTs, given their fields and symmetries.

Presenter: FONSECA, Renato (IPNP, Charles University, Prague)

Contribution ID: **18** Type: **not specified**

Matchmakereft: an automated tool for EFTs

Thursday 16 June 2022 10:00 (30 minutes)

Effective Field Theories (EFTs) provide a useful framework to connect experimental data with their implications on new physics models. However, this comparison can be highly non-trivial, especially if one-loop matching and running are taken into account. In this talk, I will briefly review the use of Matchmakereft, an automated tool to compute tree level and one-loop matching and RGEs of general models into general EFTs.

Presenter: OLGOSO, Pablo

Contribution ID: **19** Type: **not specified**

Towards a global SMEFT likelihood

Thursday 16 June 2022 12:00 (30 minutes)

I will report on recent developments concerning the Python package smelli, which implements a global likelihood function in the space of dimension-six Wilson coefficients in the Standard Model Effective Field Theory and the Weak Effective Theory above and below the electroweak scale, respectively. This likelihood can serve as a basis either for model-independent fits or for testing dynamical models.

Presenter: STANGL, Peter (University of Bern)

Contribution ID: **20** Type: **not specified**

Gauge Invariance and Finite Counterterms in Chiral Gauge Theories

Thursday 16 June 2022 15:00 (30 minutes)

We derive the finite one-loop counterterm required to restore the Ward Identities broken by the regularization scheme in chiral gauge theories. Our result is an analytic expression applicable to a wide class of regularizations satisfying a few general properties. We adopt the background field method, which ensures background gauge invariance in the quantized theory, and focus on renormalizable chiral theories with arbitrary gauge group and fermions in general representations. Our approach can be extended to theories involving scalars, such as the Standard Model, or to non-renormalizable theories, such as the SMEFT. As a concrete application, we work out the finite counterterm at one loop in the Standard Model, within dimensional regularization and the Breitenlohner-Maison-'t Hooft-Veltman prescription for gamma5.

Presenter: VECCHI, Luca (EPFL - Ecole Polytechnique Federale Lausanne (CH))

Contribution ID: **21** Type: **not specified**

Hamiltonian Truncation Effective Theory

Thursday 16 June 2022 16:30 (30 minutes)

Hamiltonian truncation is a non-perturbative numerical method for calculating observables of a quantum field theory. In this talk, I will show how to treat Hamiltonian truncation systematically using effective field theory methodology. The starting point for this method is to truncate the interacting Hamiltonian to a finite-dimensional space of states below some energy cutoff Emax. The effective Hamiltonian can be computed by matching a transition amplitude to the full theory, and gives corrections order by order as an expansion in powers of 1/Emax. This method is demonstrated using 2D λϕ4 theory, and gives 1/Emaxˆ2 corrections to the effective Hamiltonian. Numerical diagonalization of the effective Hamiltonian then shows residual errors of order 1/Emaxˆ3, as expected by our power counting.

Presenter: HOUTZ, Rachel (IPPP Durham)

Contribution ID: **22** Type: **not specified**

Modern QFT & Real-World Gravity

Thursday 16 June 2022 16:00 (30 minutes)

Presenter: LEVI, Michèle

Contribution ID: **23** Type: **not specified**

Flavour of the SMEFT

Wednesday 15 June 2022 18:00 (30 minutes)

Presenter: GRELJO, Admir (Universitaet Bern (CH))

Contribution ID: **24** Type: **not specified**

EFT for nuclear beta transitions

Wednesday 15 June 2022 18:30 (30 minutes)

Precision measurements in nuclear and neutron beta decay will be reviewed and analyzed both within the Standard Model and looking for new physics. Using an EFT description I will discuss the interplay between the different experiments and which ones are the most sensitive and promising.

Presenter: GONZALEZ-ALONSO, Martin (CERN)

Contribution ID: **25** Type: **not specified**

CP violation for baryogenesis in SMEFT

Wednesday 15 June 2022 13:00 (30 minutes)

The observed baryon asymmetry of the universe requires CP violation beyond the Standard Model for which electroweak baryogenesis is a compelling framework. This can be accommodated in higher-dimensional Yukawa terms in SMEFT. One or several complex Yukawa couplings result in an interesting interplay of requirements for successful baryogenesis as well as constraints from inclusive and differential Higgs boson measurements and electric dipole moments. To determine potentially viable scenarios, I will present the maximal baryon asymmetry realizable within the complementary constraints and their implications for a minimal and maximal New Physics scale of these SMEFT scenarios.

Presenter: FUCHS, Elina (CERN)

Contribution ID: **26** Type: **not specified**

Moments for positivity: using Drell-Yan data to test positivity bounds and reverse-engineer new physics

Thursday 16 June 2022 18:30 (30 minutes)

Moments of the leptonic angular distribution in the Drell-Yan process have recently been shown to be sensitive probes of a specific class of dimension-8, four-fermion operators in the Standard Model Effective Field Theory, involving a pair of quarks and leptons. The same operators are also subject to positivity bounds, when requiring the associated (unknown) UV completion to obey basic principles of quantum field theory. We perform a phenomenological study to quantify the sensitivity of the high-luminosity LHC to this set of operators and, by extension, the positivity bounds. We further extend the angular basis of moments and consider double differential information to improve the ability to disentangle the different operators, leading to a sensitivity to new physics scales up to 3 TeV. We use this information to explore the violation of positivity at the LHC as a way to test the underlying principles of quantum field theory. Finally, we present a case study which combines our results with information from other (current and prospective) experiments, as well as the positivity cone to infer the properties of possible tree-level UV completions. The data lead to robust, model-independent lower bounds on the $M/g^{-}\sqrt{}$ combination of the particle mass and coupling, for states that couple to right-handed leptons and/or up quarks.

Presenter: MIMASU, Ken (King's College London)

Contribution ID: **27** Type: **not specified**

Exploding operators for Majorana neutrino masses

Thursday 16 June 2022 09:30 (30 minutes)

I will describe a procedure for the automated building of simplified models starting from effective operators, and how this procedure was used to derive a large class of novel and historical neutrino-mass models using an open-source Python library. I will discuss some details of the algorithm as well as the database of neutrino-mass models that it has produced. I will conclude with possible future directions in automated model building and phenomenology. The talk will be broadly based on this paper: https://arxiv.org/abs/2009.13537.

Presenter: GARGALIONIS, John (The University of Melbourne)

Contribution ID: **28** Type: **not specified**

The top quark electro-weak couplings after LHC Run 2

Recent measurements at the Large Hadron Collider allow for a robust and precise characterisation of the electro-weak interactions of the top quark. We present the results of a global analysis at next-to-leading order precision including LHC, LEP/SLD and Tevatron data in the framework of the Standard Model Effective Field Theory. We include a careful analysis of the impact of correlations among measurements, as well as of the uncertainties in the Effective Field Theory setup itself. We find remarkably robust global fit results, with central values in good agreement with the Standard Model prediction, and 95% probability bounds on Wilson coefficients that range from ±0.35 to ±8 TeV−2. This result represents a considerable improvement over previous studies, thanks to the addition of differential cross-section measurements in associated production processes of top quarks and neutral gauge bosons. We also present new projections for future runs of the LHC with higher luminosity (the so-called HL-LHC) and a future electron-positron collider. Paper: https://link.springer.com/article/10.1007/JHEP02(2022)032 And report: https://arxiv.org/abs/2204.01882, http://arxiv.org/abs/2205.02140

Presenter: MORENO LLACER, Maria (Univ. of Valencia and CSIC (ES))

Contribution ID: **29** Type: **not specified**

Electroweak Input Schemes in the SMEFT

Thursday 16 June 2022 11:30 (30 minutes)

In recent years a great deal of work has been put into the framework that is the Standard Model Effective Field Theory. One loop calculations are currently being used to increase the precision of SMEFT predictions. Within these predictions, three Electroweak input parameters need to be decided on, with the historically accepted choice in the SM being the set {Alpha_EW, G_f, MZ}. Our work considers this choice of inputs and compares them to other, potentially more suitable, choices. We calculate the full decay rate of a number of processes up to one loop at dimension 6 in the SMEFT using three different input schemes. Comparison of the size of corrections, the number of different Wilson coefficients and the source of the Wilson coefficients appears enables discussion on the desirability of each potential input scheme allowing a more informed decision on scheme choice to be determined for future calculations.

Presenter: SMITH, Tommy (Durham University)

Contribution ID: **30** Type: **not specified**

High-pT constraints for semileptonic operators in the SMEFT

Thursday 16 June 2022 18:00 (30 minutes)

High-pT tail observables at the LHC offer a complementary probe to low-energy experiments for studying the flavor structure of the Standard Model and beyond. We discuss the high-pT tails of neutral- and charged-current Drell-Yan processes to probe New Physics (NP) effects in semileptonic transitions. For this purpose, we describe the relevant cross-sections in terms of general form-factors, which are matched to the Standard Model Effective Field Theory (SMEFT). Contributions from the exchange of new resolved bosonic mediators arising in ultraviolet models are also considered in this form-factor framework. By using the latest run-2 data from LHC on the relevant mono-lepton and di-lepton production channels, we derive constraints on the SMEFT Wilson coefficients using a consistent expansion of the observables in the NP scale Λ up to order $\mathcal{O}(\Lambda^{-4})$. At the same time, we also discuss the impact of including dimension eight operators for specific NP scenarios. Furthermore, we present the Mathematica package "HighPT", which provides a simple way to compute the relevant high-pT tail observables and to extract the complete LHC likelihood for Drell-Yan. To illustrate the relevance of these results, we revisit the leptoquark explanations of the charged-current B-physics anomalies, by exploring the complementarity of our high-pT constraints with the relevant low-energy observables.

Presenter: WILSCH, Felix

Contribution ID: **31** Type: **not specified**

Systematic matching of simple UV models for SMEFT global fits

Thursday 16 June 2022 12:30 (30 minutes)

There is an increased effort to perform global fits of current experimental results in order to find signs of New Physics. The Standard Model Effective Field Theory has become the leading framework for these efforts thanks to offering a theoretically consistent and mostly model-independent way to parameterize deviations from the SM. More recent studies aim at interpreting the results of such global EFT fits in terms of specific UV models. Here, I'll present ongoing efforts towards the systematic implementation of UV complete models in the SMEFiT global analysis framework. We obtain constraints by matching all possible 1-particle extensions of the SM with spin smaller or equal than 1 to the SMEFT. We study both tree-level and 1-loop matching and discuss the impact and subtleties of the latter. We also discuss the statistical interpretation of the resulting posterior distributions in the UV couplings and the impact of flavour assumptions.

Presenter: ROSSIA, Alejo Nahuel (University of Manchester)

Contribution ID: **32** Type: **not specified**

Probing new physics using Standard Model Effective Field Theory

Friday 17 June 2022 11:45 (30 minutes)

In the quest for new physics (NP), due to the lack of any direct evidence, the framework of Effective field theory (EFT) becomes an indirect and consistent way to parametrise NP effects in terms of higher dimension operators. Among the observables with the potential to account for NP signatures, Electroweak Precision Observables (EWPO) and those from Higgs productions and decays play an important role. In this talk, I will discuss the modifications induced by the Standard Model Effective Field Theory (SMEFT) Warsaw basis dimension-6 operators on different observables related to the electroweak sector. I will present the model-independent constraints obtained from the global fit performed using the EWPO, single and di-Higgs data, as well as distributions from the di-boson production channels. In addition, I will discuss the constraints imposed on the BSM extensions by the considered data via SMEFT matching.

Presenter: ., Anisha (University of Glasgow)

Contribution ID: **33** Type: **not specified**

Effective field theory basis and UV origin

Thursday 16 June 2022 13:00 (30 minutes)

We classify the SMEFT operators into the so-called "J-basis" that are responsible for generating local amplitude of the specific scattering channel with definite angular momenta and gauge quantum numbers. In this sense, the J-basis operators can be viewed as originating from integrating out a heavy field with the corresponding spin and gauge quantum numbers. Such a classification can lead to a complete classification of the UV origin of certain operators from a pure bottom-up approach, and can also be used as a selection rule for the non-interference effect between different amplitudes.

Presenter: HAO-LIN, Li (CP3 UCLouvain)

Contribution ID: **37** Type: **not specified**

The impact of dimension 8 operators on the 2HDM

Wednesday 15 June 2022 15:30 (30 minutes)

One of the usual assumptions in Effective Field Theories (EFTs) is to truncate the expansion with the dimension-6 operators. I discuss the relevance of including operators of dimension-8 in an EFT for the 2 Higgs Doublet Model (2HDM). I present the matching between EFT and 2HDM up to dimension 8, written in terms of well-known bases, considering a generally CP-violating 2HDM. Using the up-to-date Higgs signal strength measurements at the LHC, I convert the constraints on Wilson coefficiens into contraints of the 2HDM. I show that there are processes where dimension-8 operators plays a crucial role, as there simply is no contribution from dimension-6 operators. I also show that, whereas in some cases the inclusion of dimension-6 operators squared is enough to adequately reproduce the full model, in other cases the dimension-8 operators become signicant, without spoiling the validity of the EFT expansion.

Presenter: FONTES, Duarte (Instituto Superior Técnico, University of Lisbon)

Contribution ID: **38** Type: **not specified**

Higgs couplings at future muon colliders

Friday 17 June 2022 12:15 (30 minutes)

High-energy lepton colliders with a centre-of-mass energy in the multi-TeV range are currently considered among the most challenging and far-reaching future accelerator projects. We observe that starting from collider energies of a few TeV, electroweak (EW) vector boson fusion/scattering (VBF) at lepton colliders becomes the dominant production mode for all Standard Model processes relevant to studying the EW sector. Such a machine would effectively be a "high-luminosity weak boson collider,"and subsequently offer a wide range of opportunities to precisely measure EW and Higgs coupling as well as to discover new particles. In particular, the potential for precision physics is assessed, focusing on the prospects to determine the Higgs couplings within the SMEFT framework. Specifically, we find a clear indication that a muon collider could provide a determination of the quartic Higgs self-coupling that is significantly better than what is currently considered attainable at other future colliders.

Presenter: MANTANI, Luca (DAMTP, University of Cambridge)

Contribution ID: **39** Type: **not specified**

A reduced basis for CP violation in SMEFT at colliders and its application to diboson production

Wednesday 15 June 2022 12:00 (30 minutes)

We show that only 10 (17) CP-odd operators of the SMEFT give the leading, i.e. least suppressed by the new physics scale, CP-violating contributions once we assume that all fermions are massless but the top (and bottom) quark(s). We start with a short review of previous analyses focusing on operators of our reduced basis and list different observables probing their CP violating effects by direct measurements at colliders and by indirect measurements in low-energy observables. Since CP-odd operators typically lead to phase space suppressed interferences, we quantify the efficiency to revive the interference for various observables found in the literature but also for new observables in diboson production. Our new observables are found to be more efficient on the whole experimental fiducial phase space and are complementary to those presented so far as they probe different combinations of operators and get their sensitivities from different regions of the phase space.

Presenter: TOUCHÈQUE, Julien

Contribution ID: **40** Type: **not specified**

Quantum SMEFT tomography: top quark pair production at the LHC

Friday 17 June 2022 09:30 (30 minutes)

Quantum information observables, such as entanglement measures, provide a powerful way to characterize the properties of quantum states. We propose to use them to probe the structure of fundamental interactions and to search for new physics at high energy. Inspired by recent proposals to measure entanglement of top quark pairs produced at the LHC, we examine how higher-dimensional operators in the framework of the SMEFT modify the Standard Model expectations. We explore two regions of interest in the phase space where the Standard Model produces maximally entangled states: at threshold and in the high-energy limit. We unveil a non-trivial pattern of effects, which depend on the initial state partons, qq or gg, on whether only linear or up to quadratic SMEFT contributions are included, and on the phase space region. In general, we find that higher-dimensional effects lower the entanglement predicted in the Standard Model.

Presenter: AOUDE, Rafael

Contribution ID: **41** Type: **not specified**

The seeds of EFT double copy

Thursday 16 June 2022 15:30 (30 minutes)

Presenter: DURIEUX, Gauthier (CERN)

Contribution ID: **42** Type: **not specified**

Talk about Cen Zhang's work

Friday 17 June 2022 11:30 (15 minutes)

Presenter: DURIEUX, Gauthier (CERN)