# Higgs and Effective Field Theory - HEFT 2019

# Report of Contributions

https://agenda.irmp.ucl.ac.be/e/3283

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

# Probing Higgs couplings at future lepton colliders in the EFT framework

*Wednesday, April 17, 2019 4:30 PM (30 minutes)*

We study the reach on the Higgs coupling constraints at future lepton colliders in a global effective-field-theory framework. The impact and complementarity of different measurements, at different center-of-mass energies and for several beam polarization configurations are discussed in detail. The impact of Z-pole measurements and the complementarity with HL-LHC are also discussed.

based on arXiv:1704.02333, arXiv:1711.03978 and current work

**Primary author:** GU, Jiayin (JGU Mainz)

**Presenter:** GU, Jiayin (JGU Mainz)

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

# A Global Likelihood for Precision Constraints and Flavour Anomalies

*Monday, April 15, 2019 3:00 PM (30 minutes)*

I present a global likelihood function in the space of dimension-six Wilson coefficients in the Standard Model Effective Field Theory (SMEFT). The likelihood includes contributions from flavour-changing neutral current Bdecays, lepton flavour universality tests in charged- and neutral-current B and K decays, meson-antimeson mixing observables in the K, B, and D systems, direct CP violation in K⟶ππ, charged lepton flavour violating B, tau, and muon decays, electroweak precision tests on the Z and W poles, the anomalous magnetic moments of the electron, muon, and tau, and several other precision observables, 265 in total. The Wilson coefficients can be specified at any scale, with the one-loop running above and below the electroweak scale automatically taken care of. The implementation of the likelihood function is based on the open source tools flavio and wilson as well as the open Wilson coefficient exchange format (WCxf) and can be installed as a Python package. It can serve as a basis either for modelindependent fits or for testing dynamical models, in particular models built to address the anomalies in B-physics. I discuss a number of example applications, reproducing results from the EFT and model building literature.

**Primary author:** Dr STANGL, Peter (LAPTh Annecy)

**Co-author:** AEBISCHER, Jason (TUM)

**Presenter:** Dr STANGL, Peter (LAPTh Annecy)

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

# Higgs Couplings in Longitudially-Polarised Multibosons

*Tuesday, April 16, 2019 3:30 PM (20 minutes)*

We want to establish the reach to possible deviations of the Higgs couplings from their SM values, to do this we look at processes with longitudinally polarised vector bosons in the final states at high energies.
Especially, our analysis is grounded on the observation that deviations from the Standard Model are characterised by an energy growing behaviour in the amplitudes, so that at higher energies New Physics signatures appear stronger and compete with the loss of statistics. In the context of the High Luminosity LHC we have considered the process pp > LLLL jj, where L is a longitudinally polarised vector boson, to constraint possible deviations of the Higgs self interaction.
From the same perspective, we have also studied the process e+e- > LL at CLIC, where along with higher CM-energy values also beam polarisation is used to better constraint New Physics effects in the Higgs coupling.

**Primary authors:** Mr LOMBARDO, Davide Maria (University of Geneva); Dr RIEMBAU, Marc (University of Geneva); Mr HENNING, Brian (University of Geneva); Mr RIVA, Francesco (University of Geneva)

**Presenter:** Mr LOMBARDO, Davide Maria (University of Geneva)

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

# Unitary EChL predictions with MadGraph 5 for dynamical vector resonances emerging at VBS-LHC

*Tuesday, April 16, 2019 5:20 PM (30 minutes)*

The collider phenomenology of a strongly interacting electroweak symmetry breaking sector is studied. We use the Electroweak Chiral Lagrangian (EChL) and the Inverse Amplitude Method (IAM). And generate a MadGraph v5 UFO model, which includes the beyond Standard Model (BSM) interactions via effective vertices in the framework of a Proca Lagrangian. The constants of the Proca Lagrangian are adjusted to resemble those of the unitarized matrix elements. This project is a continuation of a previous analysis of the elastic scattering $w^+z \to w^+z$, extended to include processes involving $w^+w^- \to w^+w^-$. Several channels (fully leptonic and semileptonic) are being considered. Our final goal would be providing a complete and tested MadGraph v5 UFO model for the phenomenology of Vector Boson Scattering of the EChL unitarized via IAM, for the phenomenology and experimental community.

**Primary authors:** DELGADO LÓPEZ, Rafael (Technische Universität München); Mr GARCÍA--GARCÍA, Claudia (IFT-CSIC UAM); Prof. HERRERO SOLANS, María José (IFT-CSIC UAM)

**Presenter:** DELGADO LÓPEZ, Rafael (Technische Universität München)

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

# Master formula for one-loop renormalization of bosonic SMEFT operators

*Wednesday, April 17, 2019 4:00 PM (30 minutes)*

Using background-field method and super-heat-kernel expansion, we derive a master formula for the one-loop UV divergences of the bosonic dimension-six operators in Standard Model Effective Field Theory (SMEFT). This approach reduces the calculation of all the UV divergences to algebraic manipulations. Using this formula we corroborate results in the literature for the one-loop anomalous dimension matrix of SMEFT obtained via diagrammatic methods, considering contributions from the operators $X^3$, $\phi^6$, $\phi^4 D^2$, $X^2\phi^2$ of the Warsaw basis. The formula is derived in a general way and can be applied to other quantum field theories.

**Primary authors:** Dr KRAUSE, Claudius (Fermilab); Prof. BUCHALLA, Gerhard (LMU Munich); Dr CELIS, Alejandro (LMU Munich); Mr TOELSTEDE, Jan (LMU Munich, TU Munich)

**Presenter:** Dr KRAUSE, Claudius (Fermilab)

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

# Constraining the Higgs trilinear self-coupling at the HL-LHC and at the FCC-hh

*Wednesday, April 17, 2019 9:00 AM (30 minutes)*

In this talk, we will discuss the present status of the di-Higgs searches at the LHC. We will quantify the prospects of witnessing signatures of these elusive modes in the $b\bar{b}\gamma\gamma$, $b\bar{b}\tau^+\tau^-$, $b\bar{b}WW^*$, $WW^*\gamma\gamma$ and the $4W$ channels at the high luminosity run of the LHC (HL-LHC). We will emphasise the prospects of measuring the Higgs self-coupling at the futuristic 100 TeV FCC-hh collider when the two Higgs bosons are either produced in association with an additional hard jet or in association with a pair of top quarks. Finally, these constraints will be translated to the operator coefficients modifying the Higgs self-coupling.

**Primary authors:** BANERJEE, Shankha (IPPP, Durham University); Prof. KRAUSS, Frank (IPPP, Durham University); Prof. SPANNOWSKY, Michael (IPPP, Durham University); Mr OCHOA VALERIANO, Oscar (IPPP, Durham University); Dr GUPTA, Rick S. (IPPP, Durham University)

**Presenter:** BANERJEE, Shankha (IPPP, Durham University)

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

# Interference resurrection in $Zh$ production

*Tuesday, April 16, 2019 2:00 PM (30 minutes)*

Operators with the vertex $hZ_{\mu\nu}hZ^{\mu\nu}$ contributing to associated production of a Higgs boson with a transverse Z boson, do not interfere with the dominant longitudinal part of the $Zh$ amplitude at high energies. Here we explore how angular distributions related to the Z decay products can be used to recover the interference term and thus gain sensitivity to these operators.

**Primary authors:** GUPTA, Rick S (IPPP, Durham University); BANERJEE, Shankha (CERN - TH/SP); Prof. SPANNOWSKY, Michael (IPPP, Durham University); Mr JOEY, Reiness (IPPP Durham)

**Presenter:** GUPTA, Rick S (IPPP, Durham University)

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

# SMEFiT: A Monte Carlo global analysis of the Standard Model Effective Field Theory

*Monday, April 15, 2019 4:15 PM (30 minutes)*

We present a novel framework for carrying out global analyses of the Standard Model Effective Field Theory (SMEFT) at dimension-six: SMEFiT. This approach is based on the Monte Carlo replica method for deriving a faithful estimate of the experimental and theoretical uncertainties and enables one to construct the probability distribution in the space of the SMEFT degrees of freedom. As a proof of concept of the SMEFiT methodology, we present a first study of the constraints on the SMEFT provided by top quark production measurements from the LHC. Our analysis includes more than 30 independent measurements from 10 different processes at 8 and 13 TeV such as inclusive top-quark pair and single-top production and the associated production of top quarks with weak vector bosons and the Higgs boson. State-of-the-art theoretical calculations are adopted both for the Standard Model and for the SMEFT contributions, where in the latter case NLO QCD corrections are included for the majority of processes. We derive bounds for the 34 degrees of freedom relevant for the interpretation of the LHC top quark data and compare these bounds with previously reported constraints. Our study illustrates the significant potential of LHC precision measurements to constrain physics beyond the Standard Model in a model-independent way, and paves the way towards a global analysis of the SMEFT.

**Primary author:** Dr ROJO, Juan (VU Amsterdam and Nikhef)

**Presenter:** Dr ROJO, Juan (VU Amsterdam and Nikhef)

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

# Can New Physics hide in the proton PDFs?

*Wednesday, April 17, 2019 11:10 AM (30 minutes)*

A major recent breakthrough in global fits of the quark and gluon structure of the proton has been the inclusion of a significant amount of precision LHC measurements. While these data provide important constraints, specially on the poorly-know gluon and antiquark PDFs, it is crucial to avoid any contamination from potential beyond the Standard Model (BSM) effects that could be present in the high E or pT tails of the fitted distributions. This problem is particularly acute for LHC data from Runs II and III, as well as for the future high-luminosity run, where many PDF-sensitive observables will reach into the few TeV region. In this talk, I present a first quantitative study aiming to study whether or not BSM effects can be reabsorbed into the fitted PDFs, as well as the possibility of using the global QCD fit to simultaneously constrain both the proton structure and BSM dynamics.

**Presenter:** Dr UBIALI, Maria (DAMTP, U. of Cambridge)

Contribution ID: **13** Type: **not specified**

# Probing new physics in top decays

*Thursday, April 18, 2019 9:30 AM (30 minutes)*

New physics can manifest itself by an appreciable increase of the decay rate of top quarks in rare flavour-changing final states. Exploiting the large top quark production rate at the LHC, we bound four-fermion operators using different signal regions of the latest LHC searches for $t \to Zj$. We also provide prospects for the high-luminosity LHC to test these as well as four-fermion operators contributing to $t \to bbj$, based on improved analysis strategies of existing searches. Finally, we discuss rare top decays within extended effective-field theories.

**Primary author:** CHALA, Mikael (IPPP Durham)

**Presenter:** CHALA, Mikael (IPPP Durham)

Contribution ID: **14** Type: **not specified**

# BasisGen: automatic generation of operator bases

*Tuesday, April 16, 2019 11:30 AM (30 minutes)*

When dealing with effective Lagrangians it is often convenient to work with a basis, i.e., a complete set of independent operators. I will present BasisGen, a Python package for the automatic generation of operator bases in a general setting: it accepts any semisimple symmetry group and fields in any of its finite dimensional irreducible representations. It takes into account integration by parts redundancy and, optionally, the use of equations of motion. BasisGen is also fast: this is achieved with an implementation based on the classical representation-theoretic methods involving roots and weights.

**Primary author:** CRIADO, Juan Carlos (University of Granada)

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

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

# Constraining effective field theories with machine learning

*Thursday, April 18, 2019 11:30 AM (30 minutes)*

An important part of the LHC legacy will be precise limits on indirect effects of new physics, framed for instance in terms of an effective field theory. These measurements often involve many theory parameters and observables, which makes them challenging for traditional analysis methods. We discuss the underlying problem of "likelihood-free" inference and present powerful new analysis techniques that combine physics insights, statistical methods, and the power of machine learning. We have developed MadMiner, a new Python package that makes it straightforward to apply these techniques. In example LHC problems we show that the new approach lets us put stronger constraints on theory parameters than established methods, demonstrating its potential to improve the new physics reach of the LHC legacy measurements. While we present techniques optimized for particle physics, the likelihood-free inference formulation is much more general, and these ideas are part of a broader movement that is changing scientific inference in fields as diverse as cosmology, genetics, and epidemiology.

**Primary author:** BREHMER, Johann (New York University)

**Co-authors:** Mr CRANMER, Kyle; Ms ESPEJO, Irina; Mr KLING, Felix; Mr LOUPPE, Gilles; Mr PAVEZ, Juan

**Presenter:** BREHMER, Johann (New York University)

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

# Learning to pinpoint effective operators at the LHC: a study of the ttbb signature

*Monday, April 15, 2019 4:45 PM (20 minutes)*

In the context of the Standard Model effective field theory (SMEFT), we study the LHC sensitivity to four fermion operators involving heavy quarks by employing cross section measurements in the $t\bar{t}b\bar{b}$ final state. Starting from the measurement of total rates, we progressively exploit kinematical information and machine learning techniques to optimize the projected sensitivity at the end of Run III. Indeed, in final states with high multiplicity containing inter-correlated kinematical information, multi-variate methods provide a robust way of isolating the regions of phase space where the SMEFT contribution is enhanced. We also show that training for multiple output classes allows for the discrimination between operators mediating the production of top quarks in different helicity states. Our projected sensitivities not only constrain a host of new directions in the SMEFT parameter space but also improve on existing limits demonstrating that, on one hand, $t\bar{t}b\bar{b}$ production is an indispensable component in a future global fit for top quark interactions in the SMEFT, and on the other, multi-class machine learning algorithms can be a valuable tool for interpreting LHC data in this framework.

DOI: 10.1007/JHEP11(2018)131
ArXiv preprint: 1807.02130

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**Co-authors:** MIMASU, Ken (CP3, Université Catholique de Louvain); MARIOTTI, Alberto (Vrije Universiteit Brussel); ZHANG, Cen; D'HONDT, Jorgen (Vrije Universiteit Brussel)

**Presenter:** MOORTGAT, Seth (Vrije Universiteit Brussel (IIHE))

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

# The Higgs width in the SMEFT

*Tuesday, April 16, 2019 3:00 PM (30 minutes)*

We calculate the total and partial inclusive Higgs widths at leading order in the Standard Model Effective Field Theory (SMEFT). We report results incorporating all SMEFT corrections for two and four body Higgs decays in this limit. The narrow width approximation is avoided and all phase space integrals are directly evaluated.

**Primary authors:** CORBETT, Tyler (NBI); TROTT, Michael; BRIVIO, Ilaria

**Presenter:** CORBETT, Tyler (NBI)

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

# Gauge fixing and loop calculations in EFT

*Wednesday, April 17, 2019 3:00 PM (30 minutes)*

I will discuss the technically convenient setup for loop calculations in the EFT. First, I will present the proof that the R_xi gauge fixing can always be used in any EFT with linearly realised gauge symmetry and to any order in 1/Lambda expansion. Then, I will discuss the applications to SM-EFT on the example of systematic calculation of h->2 gamma and h->Zgamma decays: derivation of Feynman rules, gauge fixing, choice of renormalization scheme and final semi-numerical results.

**Primary author:** ROSIEK, Janusz (University of Warsaw (PL))

**Presenter:** ROSIEK, Janusz (University of Warsaw (PL))

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

# One-Loop Effective Actions

*Tuesday, April 16, 2019 12:00 PM (30 minutes)*

In this talk, we present the universal one-loop effective action obtained by integrating out massive, non-degenerate multiplets, focusing on the coefficients of operators of dimension up to six composed of Standard Model fields. Our general results may be applied to loops of non-degenerate heavy fermions or bosons.
We discuss the relationship of our results (and their ongoing improvement) to several EFTs: the SM Effective Field Theory, EFTs for the gauge bosons of some generic gauge symmetry and EFTs based on a Two Higgs Doublet Model.

**Primary author:** Dr QUEVILLON, Jérémie (LPSC (CNRS))

**Presenter:** Dr QUEVILLON, Jérémie (LPSC (CNRS))

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

# Effective field theory: on-shell & effectively

*Tuesday, April 16, 2019 10:00 AM (30 minutes)*

The study of scattering amplitudes has advanced tremendously in recent years. Lorentz symmetry and unitarity have been shown to greatly constrain the structure of both massless- and massive-particle amplitudes. In this talk, I discuss the application of these methods to the formulation and calculation of Effective Field Theory amplitudes.

**Primary author:** SHADMI, Yael (Technion)

**Presenter:** SHADMI, Yael (Technion)

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

# EFT interpretations across LHC experiments and efforts towards global analyses

*Wednesday, April 17, 2019 2:00 PM (30 minutes)*

Up to now, more than 150 $fb^{-1}$ of integrated luminosity have been collected by the CMS and ATLAS experiments at 13 TeV. These large data-sets allow challenging searches for subtle signs of generic physics beyond the standard model (BSM). A theoretical framework to describe such effects is provided by the standard model effective field theory (SMEFT) in which BSM physics is encoded via higher-dimensional operators modifying the couplings of the standard model particles. Developing a comprehensive research program to measure the coefficients of these modified couplings with highest precision is one of the main tasks of the LHC experiments in the upcoming years.
In this talk, latest experimental results on SMEFT measurements from the LHC experiments will be summarized, and a potential roadmap towards a first global analysis will be outlined using the example of the CMS experiment.

**Primary author:** GROHSJEAN, Alexander Josef (CERN - EP/UCM)

**Presenter:** GROHSJEAN, Alexander Josef (CERN - EP/UCM)

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

# Resonances and the non-linear effective theory

*Tuesday, April 16, 2019 4:50 PM (30 minutes)*

Direct searches for New Physics states have given so far negative results. There is a mass gap between SM fields and possible new states. The observed SM symmetry pattern and this mass gap justifies the use of electroweak effective Lagrangians. Implications of new, higher scales can be analyzed through next-to-leading order corrections to the Higgs Effective Theory, HEFT (also denoted as EW Effective Theory or EW Chiral Lagrangian). There are three main ingredients in our present analysis: 1st, an approximate chiral symmetry which spontaneously breaks down into custodial symmetry, as it occurs in the SM; 2nd,a non-linear realization of the EW symmetry breaking with a singlet Higgs and an assumed strongly-coupled UV-completion; 3rd, a high-energy Lagrangian which incorporates a set of new heavy states in addition to the SM degrees of freedom. We consider spin 0, 1/2 and 1 resonances, allowing for new possible coloured states. By integrating out these heavy resonances, we study the pattern of low-energy constants among the light fields. We then perform a phenomenological analysis of the low-energy constants and find that resonances with masses in the few TeV range are perfectly compatible with current experimental constraints on the low-energy parameters. The analysis of LHC diboson production through vector boson scattering (VBS) and Drell-Yan (DY) mechanisms shows that resonances in the 1.5 - 3 TeV range can easily and naturally evade all present experimental bounds: within this framework, future runs and higher luminosities will be required to be able to separate these resonances from the SM background. In the last part, we will quickly discuss possible scenarios with new physics heavy states around the TeV scale which do not couple directly to the SM fermions, only indirectly via the SM bosonic sector. This leads to an important suppression of the fermionic operators in the low-energy HEFT (bilinear and four-fermion operators) in comparison with the purely bosonic ones. This naturally suppresses VBS and DY, while leaving an imprint in SM boson measurements accessible to future experimental runs (e.g., the oblique S parameter).

**Primary author:** SANZ-CILLERO, Juan José (Universidad Complutense de Madrid - IPARCOS)

**Presenter:** SANZ-CILLERO, Juan José (Universidad Complutense de Madrid - IPARCOS)

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

# Global fits for LHC Run II and the HE-LHC

*Wednesday, April 17, 2019 12:10 PM (30 minutes)*

We present a global analysis of the Higgs and electroweak sector based on LHC Run II and electroweak precision observables using the SFitter framework. We show which measurements provide the leading constraints on Higgs-related operators, and how the achieved LHC precision makes it necessary to combine rate measurements with electroweak precision observables.
Moreover, we estimate the reach of a global analysis of the Higgs and electroweak sector for a 27 TeV hadron collider, including invisible Higgs decays and the Higgs self-coupling.

based on 1811.08401 and 1812.0758

**Primary authors:** BIEKOETTER, Anke (Uni Heidelberg); CORBETT, Tyler (NBI); PLEHN, Tilman; ZERWAS, Dirk; GONCALVES NETTO, Dorival; TAKEUCHI, Michihisa

**Presenter:** BIEKOETTER, Anke (Uni Heidelberg)

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

# EFT fits to Higgs & EW data

*Tuesday, April 16, 2019 2:30 PM (30 minutes)*

My talk will cover EFT fits to Higgs & EW data. I will show fits at LO in the EFT expansion, separately for CP-even and CP-odd operators. I will then discuss issues with extending to the next order in EFT, focussing in particular on the effect of dimension-8 operators.

**Presenter:** Prof. HAYS, Chris (University of Oxford)

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

# Precision diboson measurements at hadron colliders

*Wednesday, April 17, 2019 10:00 AM (30 minutes)*

I will discuss the measurements of the anomalous triple gauge couplings at Large Hadron Collider focusing on the contribution of the CP-even and CP-odd O3W operators. These deviations were known to be particularly hard to measure due to their suppressed interference with the SM amplitudes in the inclusive processes, leading to approximate flat directions in the space of these Wilson coefficients. I will present the prospects for the measurements of these interactions at HL-LHC and HE-LHC using exclusive variables sensitive to the interference terms and taking carefully into account effects appearing due to NLO QCD corrections.

**Presenter:** Dr BARDUCCI, Daniele (University of Rome La Sapienza)

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

# EFT harmonics

*Tuesday, April 16, 2019 9:30 AM (30 minutes)*

I will discuss developments in our understanding and construction of operator bases

**Presenter:** Dr MELIA, Tom (Kavli IPMU)

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

# New Physics in Double Higgs Production at Future $e^+e^-$ Colliders

*Wednesday, April 17, 2019 5:00 PM (20 minutes)*

We study the effects of new physics in double Higgs production at future $e^+e^-$ colliders. In the Standard Model the chiral limit ($m_e = 0$) plays an important role for this process, being responsible for the smallness of the tree-level diagrams with respect to the 1-loop contributions. In our work, we consider the possibility of an enhancement due to the contribution of Standard Model dimension-six effective operators. We show that there are only two relevant operators for this process that are not yet (strongly) constrained by other data. We perform a sensitivity study on the operator coefficients for several benchmark values of energy and integrated luminosity related to the proposed linear colliders such as CLIC, ILC and FCC-ee and we derive expected 95\% CL limits for each benchmark scenario.

**Primary authors:** DEGRANDE, Céline (CP3); Prof. ROSENFELD, Rogerio (UNESP - Universidade Estadual Paulista); Dr TONERO, Alberto (Carleton University); VASQUEZ TOCORA, Andres Felipe (UCLouvain)

**Presenter:** VASQUEZ TOCORA, Andres Felipe (UCLouvain)

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

# SMEFT, the “frog” point of view

*Tuesday, April 16, 2019 4:20 PM (30 minutes)*

There is increasing need to assess the impact and the interpretation of dim = 6 and dim = 8 operators within
the context of the Standard Model Effective Field Theory (SMEFT). The observational and mathematical consistency of a
construct based on dim = 6 and dim = 8 operators is critically examined in the light of known theoretical
results. The discussion includes elimination of redundant operators and their higher order compensation,
SMEFT in comparison with ultraviolet completions incorporating a proliferation of scalar and mixings,
canonical normalization of effective field theories, gauge invariance and gauge fixing,
role of tadpoles when constructing SMEFT at NLO, heavy-light contributions to the low energy limit of theories
containing bosons and fermions and one-loop matching.

**Presenter:** Prof. PASSARINO, Giampiero (INFN Turin & Turin U.)

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

# The Energy and Accuracy Frontier

*Thursday, April 18, 2019 9:00 AM (30 minutes)*

Accurate measurements of high-energy reactions are potentially powerful indirect probes of heavy new physics parametrised by the SMEFT. I will summarise the status of the design of searches implementing this idea in di-lepton and in di-boson final states at the LHC and HL-LHC and I will illustrate their potential mass reach on concrete new physics scenarios. A substantial progress is possible at the LHC and HL-LHC compared with present-day EW precision tests, while similar probes performed at high energy future hadron, lepton (including muon) colliders would extend the reach to tents or hundreds of TeV's. I will also outline, time permitting, the potential advantages of multivariate analyses in the di-boson channel, possibly exploiting Machine Learning techniques.

**Presenter:** Prof. WULZER, Andrea (CERN)

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

# The CKM parameters in the SMEFT

*Monday, April 15, 2019 2:30 PM (30 minutes)*

Extraction of the Cabibbo-Kobayashi-Maskawa (CKM) matrix from flavour observables can be affected by physics beyond the Standard Model (SM). We provide a general roadmap to take this into account, which we apply to the case of the Standard Model Effective Field Theory (SMEFT). We choose a set of four input observables that determine the four Wolfenstein parameters, and discuss how the effects of dimension-six operators can be included in their definition. We provide numerical values and confidence intervals for the CKM parameters, and compare them with the results of CKM fits obtained in the SM context. Our approach allows one to perform general SMEFT analyses in a consistent fashion, independently of any assumptions about the way new physics affects flavour observables. We discuss a few examples illustrating how our approach can be implemented in practice.

**Presenter:** Dr VIRTO, Javier (TUM)

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

# The golden couple of the SM: top and Higgs at present and future colliders

*Wednesday, April 17, 2019 2:30 PM (30 minutes)*

In this contribution I will discuss a number of issues that connect Higgs and top physics at present and future colliders. I will present the result of a fit to LHC data of the operator coefficients that modify the electro-weak couplings of the top and bottom quark and projections for the evolution of this fit at the HL-LHC and a future linear electron-positron collider. Finally, I will discuss how the determination of the top quark Yukawa coupling connects the top and Higgs sectors.

**Presenter:** Dr VOS, Marcel (IFIC (UVEG/CSIC) Valencia)

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

# Higgs couplings without the Higgs

*Thursday, April 18, 2019 11:00 AM (30 minutes)*

Anomalous Higgs couplings precipitate unitarity violation in a multitude of processes. These include, in particular, high multiplicity ($2 \to$ more than 2) processes involving longitudinal vectors, where unitarity violation manifests in cross-sections that grow too quickly with energy. Using EFT—which provides a transparent and systematic parameterization of the energy growth—we explore how to exploit this energy growth to measure/constrain anomalous Higgs couplings. In certain (important) channels, these high-energy probes turn out to be both complementary and competitive with standard on-shell measurements. Additionally, our exploratory analysis contains many exciting avenues for refinements and improvements for both theorists and experimentalists.

**Presenter:** Mr HENNING, Brian (University of Geneva)

Contribution ID: **34** Type: **not specified**

# Effective Theories for Precision Higgs and Flavor Physics

*Monday, April 15, 2019 2:00 PM (30 minutes)*

The talk gives an overview of recent theoretical developments in effective field theory methods as applied to the electroweak sector, particularly to the mechanism of electroweak symmetry breaking, and to flavor changing processes.

**Presenter:** MANOHAR, Aneesh (UC San Diego)

Contribution ID: **35** Type: **not specified**

# Top quark electroweak interactions at high energy

*Thursday, April 18, 2019 10:10 AM (20 minutes)*

**Presenter:** MANTANI, Luca (UCLouvain)

Contribution ID: **36** Type: **not specified**

# Compilation of low-energy constraints on 4-fermion operators in the SMEFT

*Wednesday, April 17, 2019 11:40 AM (30 minutes)*

We compile information from low-energy observables sensitive to flavor-conserving 4-fermion operators with two or four leptons. Our analysis includes data from e+ e− colliders, neutrino scattering on electron or nucleon targets, atomic parity violation, parity-violating electron scattering, and the decay of pions, neutrons, nuclei and tau leptons. We recast these data as tree-level constraints on 4-fermion operators in the Standard Model Effective Field Theory (SMEFT) where the SM Lagrangian is extended by dimension-6 operators. We allow all independent dimension-6 operators to be simultaneously present with an arbitrary flavor structure. The results are presented as a multi-dimensional likelihood function in the space of dimension-6 Wilson coefficients, which retains information about the correlations.

**Presenter:** MIMOUNI, Kin (EPFL Lausanne)

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

# EFT approach to the electron Electric Dipole Moment at the two-loop level

*Wednesday, April 17, 2019 9:30 AM (30 minutes)*

The ACME collaboration has recently reported a new bound on the electric dipole moment (EDM) of the electron, |d_e|<1.1×10^−29e·cm at 90% confidence level, reaching an unprecedented accuracy level. This can translate into new relevant constraints on theories beyond the SM laying at the TeV scale, even when they contribute to the electron EDM at the two-loop level. We use the EFT approach to classify these corrections, presenting the contributions to the anomalous dimension of the CP-violating dipole operators of the electron up to the two-loop level. Selection rules based on helicity and CP play an important role to simplify this analysis. We use this result to provide new bounds on BSM with leptoquarks, extra Higgs, or constraints in sectors of the MSSM and composite Higgs models. The new ACME bound pushes natural theories significantly more into fine-tune territory, unless they have a way to accidentally preserve CP.

**Presenter:** Dr RIEMBAU, Marc (University of Geneva)

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

# Standard Model Effective Field Theory from On-shell Amplitudes

*Tuesday, April 16, 2019 9:00 AM (30 minutes)*

We present a general method of constructing unfactorizable on-shell amplitudes (amplitude basis), and build up their one-to-one correspondence to the independent and complete operator basis in effective field theory (EFT). We apply our method to the Standard Model EFT, and identify the amplitude basis in dimension 5 and 6, which correspond to the Weinberg operator and operators in Warsaw basis except for some linear combinations.

**Presenter:** SHU, Jing (ITP Beijing)

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

# Symmetry currents and (some) consistency conditions in the SMEFT/LEFT

*Thursday, April 18, 2019 12:00 PM (30 minutes)*

**Presenter:** TROTT, Mike (NBI Copenhagen)

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

# Positivity bounds in effective field theories

*Tuesday, April 16, 2019 11:00 AM (30 minutes)*

Requiring an analytic and unitary UV completion for a low energy effective field theory (EFT) can impose positivity bounds on the Wilson coefficients of the EFT. These positivity bounds take the form of constraints on combinations of the pole subtracted scattering amplitude and its derivatives, and are valid away from the forward limit and for any spins. Furthermore, positivity bounds with nonlinear dependence on the amplitude can also be obtained. I will also discuss applications of the positivity bounds to galileon theory and standard model effective field theory.

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Contribution ID: **50** Type: **not specified**

# Welcome

*Monday, April 15, 2019 1:50 PM (10 minutes)*

**Presenter:** ORGANIZERS