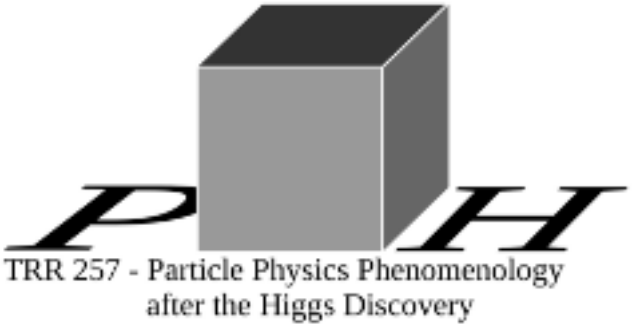
Young Scientists Meeting of the CRC TRR 257



Report of Contributions

https://indico.kit.edu/e/2690

Contribution ID: **2** Type: **talk**

Two-loop Leading Yukawa corrections to gg->HH

Friday, June 10, 2022 1:30 PM (30 minutes)

In this talk, I will present the analytic calculations of leading two-loop Yukawa corrections to the Higgs pair production in the high energy limit. These corrections are introduced by exchanging a virtual Higgs boson between top-quark lines. In particular, I will discuss the Mellin-Barnes and differential-equation methods for the calculations of fully massive two-loop box master integrals in the high energy expansions.

Authors: ZHANG, Hantian (Karlsruhe Institute of Technology); MISHIMA, Go (Karlsruhe Institute of Technology); DAVIES, Joshua (KIT); Dr SCHÖNWALD, Kay (KIT, TTP); Prof. STEINHAUSER, Matthias (KIT, TTP)

Presenter: ZHANG, Hantian (Karlsruhe Institute of Technology)

Session Classification: Young scientists talks

Contribution ID: **3** Type: **talk**

Massive quark form factors at three loops

Thursday, June 9, 2022 9:30 AM (30 minutes)

I will present our calculation of massive quark form factors at three loops in QCD.
After reducing the Feynman integrals in the amplitudes to master integrals, these were computed by solving differential equations. By constructing expansions around regular as well as singular points and numerical matching, we obtain sufficient precision over the whole kinematic range.

Authors: Dr FAEL, Matteo (KIT, TTP); Dr LANGE, Fabian (KIT, TTP + IAP); Dr SCHÖNWALD, Kay (KIT, TTP); Prof. STEINHAUSER, Matthias (KIT, TTP)

Presenter: Dr LANGE, Fabian (KIT, TTP + IAP)

Session Classification: Young scientists talks

Contribution ID: **4** Type: **talk**

$\overline{\text{MS}}$-on-shell quark mass relation with two mass scales

I will present our calculation of the $\overline{\text{MS}}$-on-shell quark mass relation allowing for two different massive quarks. We obtain complete results at the 3-loop level and some of the fermionic contributions at the 4-loop level. The results for the master integrals are obtained analytically and by constructing
series expansions around regular and singular points of the associated differential equations. By taking the limit of equal quark masses new analytical results for the quark-mass relation of a single heavy quark are found.

Author: SCHOENWALD, Kay (KIT)

Presenter: SCHOENWALD, Kay (KIT)

Session Classification: Young scientists talks

Contribution ID: **5** Type: **talk**

ttH production in the Higgs characterisation model at NLO in QCD with full off-shell effects

Friday, June 10, 2022 9:30 AM (30 minutes)

In the Standard Model, the Higgs boson is predicted to be a scalar particle. However, a possible admixture of a
$calCP$-odd component has yet to be excluded experimentally.
In this talk, I will present predictions for the associated production of a top-quark pair and a stable Higgs boson $pp \to e^+\nu_e\,\mu^-\bar{\nu}_\mu\,b\bar{b}\,H$ with possible mixing between
$calCP$-even and
$calCP$-odd states at NLO in QCD. I will compare the behaviour of the
$calCP$-even, -odd and -mixed scenarios for the integrated fiducial cross sections and several key differential distributions. In addition, I will show that both NLO corrections and off-shell effects play an important role.

Author: HERMANN, Jonathan (RWTH Aachen University)

Presenter: HERMANN, Jonathan (RWTH Aachen University)

Session Classification: Young scientists talks

Contribution ID: **6** Type: **talk**

Estimating QCD-factorization amplitudes through $SU(3)$ symmetry in $B \to PP$ decays

Thursday, June 9, 2022 3:30 PM (30 minutes)

In this talk we estimate the potential size of the weak annihilation amplitudes in QCD factorization as allowed by experimental data by establishing a connection between the amplitudes in the QCD factorization and the so-called topological and SU(3)-invariant descriptions. Our approach is based purely on the analysis of the tensor structure of the decay amplitudes. By focusing on the decay processes to two pseudoscalar mesons B⟶PP, and by considering data from CP asymmetries and branching fractions, we perform a global fit to the SU(3)-irreducible quantities. Then, we translate the outcome to the QCD factorization decomposition, and find that the most constrained weak annihilation amplitudes are below 4%. But, in view of the large uncertainties in several of the experimental input parameters, values up to 30% are allowed in certain cases.

Authors: TETLALMATZI-XOLOCOTZI, Gilberto (University of Siegen); HUBER, Tobias (Siegen U)

Presenter: TETLALMATZI-XOLOCOTZI, Gilberto (University of Siegen)

Session Classification: Young scientists talks

Contribution ID: **7** Type: **talk**

Interplay between an SFOEWPT and Higgs pair production in a 2HDM-EFT

By extending the 2-Higgs Doublet Model (2HDM) by scalar dimension-6 effective field theory (EFT) operators we investigate to which extent the addition of these higher-dimensional operators can promote the electroweak phase transition to a strong first-order electroweak phase transition (SFOEWPT). We analyze the interplay between the choice of Wilson coefficients inducing an SFOEWPT and the generated size of the LHC Higgs pair production cross section in this 2HDM-EFT.

Authors: Dr ., Anisha (Indian Institute of Technology Kanpur, University of Glasgow); Prof. ENGLERT, Christoph (University of Glasgow); Ms BIERMANN, Lisa (Karlsruhe Institute of Technology); Prof. MÜHLLEITNER, Milada Margarete (Karlsruhe Institute of Technology)

Presenter: Ms BIERMANN, Lisa (Karlsruhe Institute of Technology)

Session Classification: Young scientists talks

Contribution ID: **8** Type: **talk**

Higgs Pair Production in a Composite 2HDM

Wednesday, June 8, 2022 1:30 PM (30 minutes)

The Composite 2-Higgs-Doublet Model (C2HDM) is a composite Higgs Model where two Higgs doublets arise as pseudo Nambu-Goldstone bosons in order to retrieve the well known 2HDM but with couplings already predetermined by the composite nature of the model. Fermion masses are generated through partial compositeness entailing new heavy fermions. In this talk we present Higgs Pair production in this model via gluon fusion, including higher order QCD corrections. We investigate the impact of the higher-order corrections as well as the impact of the compositeness nature of the model with the new heavy fermions on the phenomenology of Higgs pair production. The theoretical calculation is described in detail and specific benchmark scenarios are explored.

Authors: DE CURTIS, Stefania (Universita e INFN, Firenze (IT)); DELLE ROSE, Luigi (IFAE); EGLE, Felix (Institute for Theoretical Physics (ITP), Karlsruhe Institute of Technology (KIT)); MORETTI, Stefano (School of Physics and Astronomy, University of Southampton); MÜHLLEITNER, Milada Margarete (Institute for Theoretical Physics (ITP), Karlsruhe Institute of Technology (KIT)); SAKURAI, Kodai (Department of Physics, Tohoku University)

Presenter: EGLE, Felix (Institute for Theoretical Physics (ITP), Karlsruhe Institute of Technology (KIT))

Session Classification: Young scientists talks

Contribution ID: **9** Type: **talk**

Predictions for $gg \to hh$ at full NLO QCD comparing non-linear and linear EFT frameworks and truncation effects

Friday, June 10, 2022 2:00 PM (30 minutes)

We present results for Higgs boson pair production in gluon fusion including both, NLO (2-loop) QCD corrections with full top quark mass dependence as well as anomalous couplings related to operators describing effects of physics beyond the Standard Model. The latter can be realized in non-linear (HEFT) or linear (SMEFT) Effective Field Theory frameworks. We show results for both and discuss the impact of different truncation options within the SMEFT description.

Author: LANG, Jannis (Institute for Theoretical Physics, Karlsruhe Institute of Technology (KIT))

Co-authors: HEINRICH, Gudrun (KIT); Dr SCYBOZ, Ludovic (Rudolf Peierls Centre for Theoretical Physics, Parks Road, Oxford OX1 3PU)

Presenter: LANG, Jannis (Institute for Theoretical Physics, Karlsruhe Institute of Technology (KIT))

Session Classification: Young scientists talks

Contribution ID: **10** Type: **talk**

Production and decay of the Higgs boson in association with top quarks

Friday, June 10, 2022 9:00 AM (30 minutes)

We report on the calculation of the Higgs production and decay in association with top quarks in the di-leptonic channel at NLO QCD. All resonant, non-resonant Feynman diagrams and off-shell effects are included for the top quark and W boson. We examine the size of these off-shell effects by a comparison to the narrow-width approximation. Higgs boson decays are included in the narrow-width approximation. Numerical results are given at the integrated and differential level for various factorisation and renormalisation scales and different PDF sets to asses the main theoretical uncertainties. The impact of bottom quarks in the initial state is investigated.

Author: STREMMER, Daniel (RWTH Aachen University)

Presenter: STREMMER, Daniel (RWTH Aachen University)

Session Classification: Young scientists talks

Contribution ID: **11** Type: **talk**

NRQCD matching coefficients with two mass scales

Thursday, June 9, 2022 10:00 AM (30 minutes)

NRQCD is a non-relativistic effective theory used, for example, to describe QCD bound states such as the $\Upsilon(1S)$ meson. The matching of the effective theory NRQCD to the full theory QCD requires the calculation of matching coefficients. One of these matching coefficients, the matching coefficient of the vector current, plays an important role in the calculation of the decay width of the $\Upsilon(1S)$ meson. The talk will focus on the calculation of this coefficient including two mass scales up to NNLO. Also the calculation of the scalar, pseudoscalar and axialvector current matching coefficients are presented.

Authors: Mr EGNER, Manuel (KIT TTP); Dr FAEL, Matteo (KIT TTP); Dr SCHOENWALD, Kay (KIT TTP); Prof. STEINHAUSER, Matthias (KIT TTP)

Presenter: Mr EGNER, Manuel (KIT TTP)

Session Classification: Young scientists talks

Contribution ID: **12** Type: **talk**

Phenomenology of ttbb at the LHC

Friday, June 10, 2022 10:00 AM (30 minutes)

The Higgs boson production channel $t\bar{t}H(H \to b\bar{b})$ is a crucial ingredient to study the top-Yukawa coupling but suffers of a huge background. The direct $t\bar{t}b\bar{b}$ production represents one of the main backgrounds to this process and, therefore, needs to be described properly. In this talk I will present the latest theoretical results obtained in the dileptonic decay channel. These predictions are NLO accurate in QCD and include all the full off-shell effects. I will also discuss several effects that affect this process and provide a prescription to distinguish the nature of the various b-jets present in the final state.

Author: LUPATTELLI, Michele (RWTH Aachen University)

Presenter: LUPATTELLI, Michele (RWTH Aachen University)

Session Classification: Young scientists talks

Contribution ID: **13** Type: **talk**

Searching for dark radiation at the LHC

Thursday, June 9, 2022 11:00 AM (30 minutes)

Ultra-relativistic particles can be produced by the decay of weak-scale LLPs and act as dark radiation. The cosmologically interesting range $\Delta N_{\text{eff}} \sim 0.01$–$0.1$ corresponds to LLP decay lengths at the mm scale. These decay lengths lie at the boundary between prompt and displaced signatures at the LHC. We consider a scenario where the LLP decays into a lepton and a (nearly) massless invisible particle. By reinterpreting searches for promptly decaying sleptons and for displaced leptons we can then compare LHC exclusions with cosmological observables. We find that the CMB-S4 target value is already excluded by current LHC searches.

Authors: Dr BERNREUTHER, Elias (Fermi National Accelerator Laboratory); Prof. KAHLHOEFER, Felix (KIT); Dr LUCENTE, Michele (RWTH); MORANDINI, Alessandro (RWTH Aachen University)

Presenter: MORANDINI, Alessandro (RWTH Aachen University)

Session Classification: Young scientists talks

Contribution ID: **14** Type: **talk**

On phase-space integrals with Heaviside functions

Wednesday, June 8, 2022 3:00 PM (30 minutes)

In this talk I discuss peculiarities that arise in the computation of real-emission contributions to observables that contain Heaviside functions. Specifically I will discuss the calculation of the zero-jettiness soft function in SCET at next-to-next-to-next-to-leading order in perturbative QCD. The Heaviside functions prevent a direct use of multi-loop methods based on reverse unitarity. I will present a way to bypass this problem and illustrate key aspects of the calculation. Finally I will present some results for various non-trivial contributions to the zero-jettiness soft function.

Author: BARANOWSKI, Daniel (KIT)

Co-authors: MELNIKOV, Kirill (TTP KIT); DELTO, Max (TUM); WANG, Chen-Yu

Presenter: BARANOWSKI, Daniel (KIT)

Session Classification: Young scientists talks

Contribution ID: **15** Type: **talk**

Non-Perturbative Calculations for B-mesons

Thursday, June 9, 2022 4:30 PM (30 minutes)

We present the current status of work to determine non-perturbative contributions to the physics of B-mesons.
Using the methods of lattice QCD, QCD sum rules, and the gradient flow, we consider quantities such as decay constants, dimension-6 and -7 matrix elements for lifetimes, and dimension-7 matrix elements for mixing.

Author: BLACK, Matthew (University Siegen)

Presenter: BLACK, Matthew (University Siegen)

Session Classification: Young scientists talks

Contribution ID: **16** Type: **talk**

NLO QCD corrections to inclusive $b \to c\ell\bar{\nu}$ decay spectrum up to $1/m_b^3$

Thursday, June 9, 2022 5:00 PM (30 minutes)

We present analytical results for higher order corrections to the decay spectrum of inclusive semileptonic heavy hadron weak decays using the heavy quark expansion (HQE). We describe the analytical computation of the spectrum of the leptonic invariant mass for $B \to X_c\ell\bar{\nu}$ up to terms of order $1/m_b^3$ within the HQE at next-to-leading order (NLO) in α_s. The full dependence of the differential rate on the mass of the final-state quark is taken into account. We discuss the implications of our results for the precision determination of the CKM matrix element $|V_{\rm cb}|$.

Authors: Prof. MANNEL, Thomas (Siegen University); Dr MORENO, Daniel (Siegen University); Prof. PIVOVAROV, Alexei A. (Siegen University)

Presenter: Dr MORENO, Daniel (Siegen University)

Session Classification: Young scientists talks

Contribution ID: **17** Type: **talk**

AutoEFT: Automating Effective Field Theories

Wednesday, June 8, 2022 2:00 PM (30 minutes)

In practical applications for effective field theories, it is often necessary to obtain a complete set of independent operators, but constructing such an operator basis is remarkably challenging. In this talk, I will report on our implementation of a recently proposed group-theoretical algorithm that systematically accounts for the redundancies arising from equations of motion and integration-by-parts identities among the operators. AutoEFT can be applied to phenomenologically relevant theories such as the Standard Model or extensions of it, including new light particles and additional symmetry groups.

Authors: HARLANDER, Robert (RWTH Aachen University); Mr KEMPKENS, Tim (RWTH Aachen University); Mr LINDER, Jakob (RWTH Aachen University); SCHAAF, Magnus (RWTH Aachen University)

Presenter: SCHAAF, Magnus (RWTH Aachen University)

Session Classification: Young scientists talks

Contribution ID: **18** Type: **talk**

Tasting Flavoured Majorana Dark Matter

Thursday, June 9, 2022 11:30 AM (30 minutes)

I will discuss a flavoured dark matter (DM) model set up in the so called Dark Minimal Flavour Violation (DMFV) framework. The model extends the Standard Model by a DM flavour triplet and a scalar mediator, through which the new dark fermions couple to right-handed up-type quarks. This interaction is governed by a new coupling matrix which is assumed to constitute the only new source of flavour and CP violation. After briefly presenting the details of this simplified model and the DMFV framework in the first part, I will continue and discuss its phenomenology in the context of collider, flavour, cosmology and direct detection constraints. I will further ‚taste‘ the flavour of the DM field by discussing which DM flavour is preferred after a combined analysis of all experimental constraints mentioned above. In the last part, I will present an estimation of the direct CP asymmetry in charm decays in this model and conclude my talk by discussing if it is capable of explaining the large measured value of this asymmetry.

Author: Mr ACAROGLU, Harun (Karlsruhe Institute of Technology)

Co-author: Ms BLANKE, Monika (Karlsruhe Institute of Technology)

Presenter: Mr ACAROGLU, Harun (Karlsruhe Institute of Technology)

Session Classification: Young scientists talks

Contribution ID: **19** Type: **talk**

The heavy meson lifetimes

Thursday, June 9, 2022 4:00 PM (30 minutes)

(Part of the CRC project **C1b**)

In this talk, I plan to discuss the current status of theory predictions for lifetimes of heavy $H = B, D$-mesons (containing a heavy quark $Q = b, c$), which can be presented schematically within the Heavy Quark Expansion (HQE) framework as:
$\Gamma(H) = \Gamma_3 + \Gamma_5 \frac{\langle calO_5 \rangle}{m_Q^2} + \Gamma_6 \frac{\langle calO_6 \rangle}{m_Q^3} + ... + 16\pi^2 \left[\tilde{\Gamma}_6 \frac{\langle \tilde{\mathcal{O}}_6 \rangle}{m_Q^3} + \tilde{\Gamma}_7 \frac{\langle \tilde{\mathcal{O}}_7 \rangle}{m_Q^4} + ... \right], where$
cal O_d denotes the effective operator of dimension d, with the matrix element $\langle calO_d \rangle \equiv \langle H | calO_d | H \rangle$, and Γ_d is the corresponding short-distance Wilson coefficient. Then I will discuss more in detail the recent first determination of Darwin operator contribution Γ_6. In addition, I will present some results on the phenomenology, and will discuss further prospects and plans on improvement of the HQE predictions for these lifetimes - both from perturvative and non-perturbative side - by the Siegen and Karlsruhe Universities.

Author: RUSOV, Aleksey (University of Siegen)

Presenter: RUSOV, Aleksey (University of Siegen)

Session Classification: Young scientists talks

Contribution ID: **20** Type: **talk**

Mixed QCD-electroweak corrections to Higgs plus jet production at the LHC

Friday, June 10, 2022 1:00 PM (30 minutes)

The detailed study of the Higgs boson is one of the main tasks of contemporary particle physics. Gluon fusion, the main production channel of Higgs bosons at the LHC, has been successfully tackled up to N^{3}LO in QCD. To fully exploit this unprecedented theoretical effort, sub-leading contributions, such as electroweak corrections, must be investigated. I will present the analytic calculations of the gluon- and quark-induced Higgs plus jet amplitudes in mixed QCD-electroweak corrections mediated by light quarks up to order $v\alpha^2\alpha_S^{3/2}$.

Authors: BONETTI, Marco (RWTH TTK); Dr PANZER, Erik (All Souls College, University of Oxford); Dr SMIRNOV, Vladimir A. (Skobeltsyn Institute of Nuclear Physics of Moscow State University, Moscow Center for Fundamental and Applied Mathematics); Prof. TANCREDI, Lorenzo (TUM)

Presenter: BONETTI, Marco (RWTH TTK)

Session Classification: Young scientists talks

Contribution ID: **21** Type: **talk**

Multi-emission kernels for parton branching algorithms

Friday, June 10, 2022 11:30 AM (30 minutes)

We will discuss a novel framework for addressing QCD factorization in the emission of multiple soft or collinear partons. The purpose of this discussion is to allow for a more precise description of hadron collider data and to better handle theoretical uncertainties from parton showers.
We have developed a power counting algorithm in emission amplitudes with the goal of parameterizing the accuracy of different types of parton showers. An example are inaccuracies introduced by iterating single emission amplitudes vs. the use of a multi-emission kernel. Eventually, this approach should pave to way for higher orders in QCD in parton showers.

Authors: LÖSCHNER, Maximilian (KIT/ ITP); Dr PLÄTZER, Simon (University of Graz); Dr SIMPSON-DORE, Emma

Presenter: LÖSCHNER, Maximilian (KIT/ ITP)

Session Classification: Young scientists talks

Contribution ID: **22** Type: **talk**

An automated framework to calculate jet functions at NNLO

Wednesday, June 8, 2022 3:30 PM (30 minutes)

We present a novel formalism to calculate jet functions automatically at next-to-next-to-leading order in perturbation theory. By employing suitable phase-space parameterisations in combination with
sector-decomposition steps and selector functions, we managed to factorise all divergences in the phase-space integrations, and we implemented our framework in the publicly available code pySecDec.
Our approach covers a wide class of SCET-1 and SCET-2 observables, and we present results for several event-shape observables for both quark and gluon jet functions.

Authors: BELL, Guido (University of Siegen); DAS, Goutam (University of Siegen); Mr WALD, Marcel (University of Siegen); BRUNE, Kevin (University of Siegen)

Presenter: BRUNE, Kevin (University of Siegen)

Session Classification: Young scientists talks

Contribution ID: **23** Type: **talk**

Precision Test of the Muon-Higgs Coupling at a High-energy Muon Collider

Friday, June 10, 2022 11:00 AM (30 minutes)

I will present a sensitivity test of the muon-Higgs coupling at a high-energy muon collider. This is motivated if there exists new physics that is not aligned with the Standard Model Yukawa interactions which are responsible for the fermion mass generation. With the accidentally small value of the muon Yukawa coupling and its subtle role in the high-energy production of multiple (vector and Higgs) bosons, I will show that it is possible to measure the muon-Higgs coupling to an accuracy of ten percent for a 10 TeV muon collider and a few percent for a 30 TeV machine by utilizing the three boson production, potentially sensitive to a new physics scale about Λ 30 – 10 TeV.

Author: STRIEGL, Tobias (Universität Siegen)

Presenter: STRIEGL, Tobias (Universität Siegen)

Session Classification: Young scientists talks

Contribution ID: **24** Type: **talk**

How to write a successful application

Thursday, June 9, 2022 1:30 PM (30 minutes)

Presenter: LENZ, Alexander (Siegen University)

Session Classification: Soft skills training

Contribution ID: **25** Type: **talk**

DFG funding opportunities for early career researchers

Thursday, June 9, 2022 1:00 PM (30 minutes)

Presenter: KRÄMER, Michael (RWTH Aachen University)

Session Classification: Soft skills training

Contribution ID: **26** Type: **talk**

The SMEFT program at the LHC

Thursday, June 9, 2022 2:00 PM (1 hour)

The LHC experiments are entering a precision era, where the sensitivity to indirect effects of new physics, i.e. discrepancies between data and SM predictions, will increase substantially. Searches for these signals are most conveniently performed within the framework of the Standard Model Effective Field Theory (SMEFT), that allows to implement a very ambitious program: a systematic search for inconsistencies with SM predictions in a large number of different processes, from which "agnostic" information about new physics can be extracted via a combined SMEFT interpretation. The talk will give a pedagogical introduction to the SMEFT, present the current status of this effort, illustrating some recent theory developments, and briefly discuss perspectives for the future.

Author: BRIVIO, Ilaria

Presenter: BRIVIO, Ilaria

Session Classification: Invited talks

Contribution ID: **27** Type: **talk**

Precise predictions for vector-boson scattering

Friday, June 10, 2022 2:30 PM (1 hour)

The scattering of massive electroweak vector bosons allows for sensitive tests of the mechanism of the electroweak symmetry breaking. In run 2 of the LHC several of these processes have been observed, and measurements with higher precision and for polarised bosons will happen in future runs. In this talk I review the status of theoretical predictions for vector-boson scattering processes. I discuss some details of the calculations and a selection of results. Moreover, the origin of large electroweak and QCD corrections is explained.

Author: DENNER, Ansgar

Presenter: DENNER, Ansgar

Session Classification: Invited talks

Contribution ID: **28** Type: **talk**

Working outside academia - An actuary's experience

Wednesday, June 8, 2022 4:00 PM (45 minutes)

After providing a quick overview of what my daily work entails, I will offer a few remarks about my decision of leaving academia and personal experience of applying to several (German) companies. I plan to leave enough time for discussion, so bring your own questions!

Presenter: ORTA, Andrea

Session Classification: Soft skills training

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

Picture a Scientist

Wednesday, June 8, 2022 5:20 PM (1h 40m)

Picture a Scientist is a 2020 documentary highlighting gender inequality in science

Session Classification: Gender equality in academia