

RADCOR 2019

Report of Contributions

Contribution ID: 2

Type: **not specified**

QFT with FDR

Thursday, September 12, 2019 3:30 PM (25 minutes)

I discuss the latest developments of FDR in the context of Quantum Field Theory calculations relevant for High Energy Physics phenomenology. In particular, I focus on NNLO computations and the use of FDR in connection to effective QFTs.

Primary author: PITTAU, Roberto (Universidad de Granada (ES))

Presenter: PITTAU, Roberto (Universidad de Granada (ES))

Session Classification: Thursday Afternoon A

Track Classification: F

Contribution ID: 5

Type: **not specified**

Higher order corrections to Higgs boson pair production

Friday, September 13, 2019 9:30 AM (25 minutes)

In this talk we discuss NNLO and N3LO order corrections to the process $gg \rightarrow HH$ in the Standard Model. In particular, we consider three-loop corrections to the form factors entering the virtual corrections in the large- m_t limit and compute five expansion terms. In the same approximation we also evaluate the real radiation corrections at NNLO. Finally, we present a building block for the N3LO corrections, namely the four-loop matching coefficient for the effective coupling of two Higgs bosons to gluons.

Primary author: STEINHAUSER, Matthias (KIT)

Presenter: STEINHAUSER, Matthias (KIT)

Session Classification: Friday Morning

Track Classification: H

Contribution ID: 6

Type: **not specified**

ISR and IFI in Precision AFB Studies with KKMC-hh

Thursday, September 12, 2019 5:30 PM (25 minutes)

KKMC-hh is a precision event generator for Z boson production at a hadron collider, based on coherent exclusive exponentiation (CEEX) of soft photon emission at the amplitude level. We will summarize studies of ISR and IFI effects on calculations AFB for precision EW analysis at the LHC. Different approaches to ISR will be compared, and progress will be reported on implementing NLO QCD in KKMC-hh.

Primary author: YOST, Scott (The Citadel)

Presenters: YOST, Scott Alan (The Citadel - The Military College of South Carolina (US)); YOST, Scott (The Citadel)

Session Classification: Thursday Afternoon B

Contribution ID: 7

Type: **not specified**

LHC observables with NNLOJET

Monday, September 9, 2019 10:00 AM (25 minutes)

In this talk, I aim to review the phenomenology of LHC observables, related to processes newly implemented in the NNLOJET parton level event generator.

Primary author: Prof. GEHRMANN-DE RIDDER, Aude (ETH Zurich)

Presenter: Prof. GEHRMANN-DE RIDDER, Aude (ETH Zurich)

Session Classification: Monday Morning

Track Classification: N2

Contribution ID: 8

Type: **not specified**

Master integrals for all unitarity cuts of massless 4-loop propagators

Wednesday, September 11, 2019 9:00 AM (25 minutes)

Among the unitarity cuts of massless 4-loop propagators two classes remain unknown: 2-loop 3-particle, and 1-loop 4-particle cuts. I'd like to fill this gap and present the calculation of master integrals for both of these cuts. I would also like to discuss the ongoing work of using those to compute semi-inclusive phase-space integrals relevant to the calculation of NNLO time-like splitting functions.

Primary author: MAHERIA, Vitalii

Presenter: MAHERIA, Vitalii

Session Classification: Wednesday Morning B

Track Classification: P

Contribution ID: 9

Type: **not specified**

Role of IR-improvement in Precision LHC/FCC Physics and in Quantum Gravity

Thursday, September 12, 2019 6:00 PM (25 minutes)

IR-improvement based on amplitude-level resummation allows one to control unintegrable results in quantum field theory with arbitrary precision in principle. We illustrate such resummation in specific examples in precision LHC and FCC physics and in quantum gravity.

Primary authors: WARD, Bennie (Baylor University (US)); JADACH, Staszek (Polish Academy of Sciences (PL)); YOST, Scott Alan (The Citadel - The Military College of South Carolina (US)); WAS, Zbigniew Andrzej (Polish Academy of Sciences (PL))

Presenter: WARD, Bennie (Baylor University (US))

Session Classification: Thursday Afternoon B

Track Classification: MI

Contribution ID: 10

Type: **not specified**

Cross section ratios as a precision tool for ttgamma at the LHC

Thursday, September 12, 2019 11:30 AM (25 minutes)

With the goal of increasing the precision of NLO QCD predictions for the $pp \rightarrow t\bar{t}\gamma$ process in the di-lepton top quark decay channel we present theoretical predictions for the cross section ratio. Results for the latter together with various differential cross section ratios will be presented for the LHC Run II energy of 13 TeV. Fully realistic NLO QCD computations for both $t\bar{t}$ and $t\bar{t}\gamma$ production will be discussed as well.

Primary author: WOREK, Malgorzata (RWTH Aachen University)

Presenter: WOREK, Malgorzata (RWTH Aachen University)

Session Classification: Thursday Morning B

Track Classification: T

Contribution ID: 11

Type: **not specified**

QED challenges at FCC-ee precision measurements

Tuesday, September 10, 2019 5:30 PM (25 minutes)

The expected experimental precision of the rates and asymmetries in the Future Circular Collider with electron positron beams (FCC-ee) in the energy range 88-365GeV considered for construction in CERN, will be better by a factor 5-200.

This will be thanks to very high luminosity, factor up to 10^5 higher than in the past LEP experiments.

This poses the extraordinary challenge of improving the precision of the Standard Model predictions by a comparable factor.

In particular the perturbative calculations of the trivial QED effects, which have to be removed from the experimental data, are considered to be a major challenge for almost all quantities to be measured at FCC-ee.

The task of this paper is to summarize on the “state of the art” in this class of the calculations left from the LEP era and to examine what is to be done

to match the precision of the FCC-ee experiments – what kind of technical advancements are necessary.

The above analysis will be done for most important observables of the FCC-ee like the total cross sections near Z and WW threshold, charge asymmetries, the invisible width of Z boson, the spin asymmetry from tau lepton decay and the luminosity measurement.

Primary author: Prof. STANISLAW, Jadach (IFJ PAN, Kraków)

Presenter: Prof. STANISLAW, Jadach (IFJ PAN, Kraków)

Session Classification: Tuesday Afternoon B

Track Classification: E

Contribution ID: 12

Type: **not specified**

Charm mass dependent NNLO corrections to $\mathcal{B}(\bar{B} \rightarrow X_s \gamma)$

Tuesday, September 10, 2019 4:00 PM (25 minutes)

The inclusive radiative decay of the B meson is known to provide strong constraints on new particles and their interactions. The current experimental world average for its branching ratio is $(3.32 \pm 0.15) \cdot 10^{-4}$ which agrees within one sigma with the present SM prediction $(3.36 \pm 0.23) \cdot 10^{-4}$. Some of the NNLO QCD corrections are included with the help of interpolation in the charm quark mass, which causes about 3 percent uncertainty in present SM prediction. Efforts towards removing this uncertainty is the topic of talk. We will present charm quark mass dependent contributions that require evaluation of two scales four-loop propagator diagrams with unitarity cuts.

Primary authors: MISIAK, Mikolaj (University of Warsaw (PL)); REHMAN, Abdur (KIT, NCP (PK)); STEINHAUSER, Matthias (KIT)

Presenter: REHMAN, Abdur (KIT, NCP (PK))

Session Classification: Tuesday Afternoon A

Track Classification: B

Contribution ID: 13

Type: **not specified**

Evolution equation for B-meson distribution amplitude at two loops

Thursday, September 12, 2019 9:00 AM (25 minutes)

The B-meson distribution amplitude is defined by the matrix element of a heavy-light quark operator between the vacuum and B-meson states. The scale dependence of the corresponding DA is governed by the renormalization group equation for this operator. At one loop the corresponding evolution kernel was derived by Lange and Neubert. I'll argue that the form of the kernel is strongly restricted by the conformal symmetry and present the answer for the two-loop kernel.

Primary author: MANASHOV, Alexander (Hamburg University)

Presenter: MANASHOV, Alexander (Hamburg University)

Session Classification: Thursday Morning B

Contribution ID: 15

Type: **not specified**

Renormalization schemes for mixing angles

Thursday, September 12, 2019 4:00 PM (25 minutes)

The proper renormalization of mixing angles in quantum field theories is a long-standing problem. It is relevant for the renormalization of the quark mixing matrix in the Standard Model and for various mixing scenarios in theories beyond. In this talk we specifically consider theories with extended scalar sectors. We review existing renormalization schemes for mixing angles and introduce new ones based on on-shell conditions or symmetry requirements such as rigid or background-field gauge invariance. Considering in particular the renormalization of the mixing angles in the Two-Higgs-Doublet Model and the Higgs-Singlet Extension of the Standard Model, we compare electroweak corrections within these models for a selection of renormalization schemes.

Primary author: DENNER, Ansgar (Julius Max. Universitaet Wuerzburg (DE))

Co-authors: DITTMAYER, Stefan (Albert Ludwigs Universitaet Freiburg (DE)); LANG, Jean-Nicolas (University of Zurich)

Presenter: DENNER, Ansgar (Julius Max. Universitaet Wuerzburg (DE))

Session Classification: Thursday Afternoon A

Track Classification: F

Contribution ID: 16

Type: **not specified**

The R*-method: Recent applications and developments

Tuesday, September 10, 2019 11:00 AM (25 minutes)

The R*-method is a powerful tool to calculate anomalous dimensions of local QFTs. I will present new results which have been obtained with the method, such as the first few Mellin moments of splitting functions at N4LO, which also allowed us to obtain a first numerical estimate of the cusp anomalous dimension at five loops, and a calculation of the anomalous dimension of Weinberg's dimension-6 gluonic operator at 2 and 3 loops which is relevant for EDM measurements. Furthermore, I will present a new Hopf algebraic formulation which generalizes the Connes-Kreimer Hopf algebra.

Primary author: HERZOG, Franz (Nikhef)

Presenter: HERZOG, Franz (Nikhef)

Session Classification: Tuesday Morning A

Contribution ID: 17

Type: **not specified**

On the four-loop form factors of massless QCD

Wednesday, September 11, 2019 12:00 PM (25 minutes)

In this talk, we discuss our ongoing calculation of the four-loop form factors of massless QCD. In particular, we present results for the quark and gluon form factors which we have calculated for the first time using novel computational techniques.

Primary authors: SCHABINGER, Robert; VON MANTEUFFEL, Andreas (Michigan State University)

Presenter: SCHABINGER, Robert

Session Classification: Wednesday Morning B

Contribution ID: 18

Type: **not specified**

Non-factorizable QCD Effects in Higgs Boson Production via Vector Boson Fusion

Monday, September 9, 2019 4:00 PM (25 minutes)

We discuss nonfactorizable QCD corrections to Higgs boson production in vector boson fusion at the Large Hadron Collider. We point out that these corrections can be computed in the eikonal approximation retaining all the terms that are not suppressed by the ratio of the transverse momenta of the tagging jets to the total center-of-mass energy. Our analysis shows that in certain kinematic distributions the nonfactorizable corrections can be as large as a percent making them quite comparable to their factorizable counter-parts.

Primary author: PENIN, Alexander (University of Alberta)

Presenter: PENIN, Alexander (University of Alberta)

Session Classification: Monday Afternoon

Contribution ID: 19

Type: **not specified**

On the choice of variables in IBP reductions

Tuesday, September 10, 2019 9:30 AM (25 minutes)

As part of a project to derive parametric reduction schemes automatically a systematic search has been set up to determine 'good sets of variables'. It turns out that both the ease of derivation of a scheme and its efficiency depend very sensitively on the choice of variables. For some topologies there can be thousands of such choices. I report here on this search and the resulting automatic derivations of practical schemes. As an example I use four loop massless propagator topologies, but the results are applicable for more complicated reactions with fewer loops as well.

Primary author: VERMASEREN, Jos

Presenter: VERMASEREN, Jos

Session Classification: Tuesday Morning A

Contribution ID: 20

Type: **not specified**

Four-Loop Higgs- and Z-Decay and the Five-Loop Beta-Function

Wednesday, September 11, 2019 11:00 AM (25 minutes)

Recent results concerning Higgs- and Z-boson decay rate in order α^{**4} and the five-loop beta-function are presented.

Primary author: KUEHN, Johann

Presenter: KUEHN, Johann

Session Classification: Wednesday Morning B

Contribution ID: 21

Type: **not specified**

Off-shell renormalization of spontaneously broken effective gauge theories

Thursday, September 12, 2019 5:00 PM (25 minutes)

The consistent recursive subtraction of UV divergences order by order in the loop expansion for spontaneously broken effective gauge theories with higher dimension derivative operators is presented. The Slavnov-Taylor identity is solved to all orders in the loop expansion by homotopy techniques and a suitable choice of invariant field coordinates (named bleached variables) for the linearly realized gauge group. This allows one to disentangle the gauge-invariant contributions to off-shell 1-PI amplitudes from those associated with the gauge-fixing and (generalized) non-polynomial field redefinitions (that do appear already at one loop). Explicit examples for dimension-6 operators are presented.

Primary authors: QUADRI, Andrea (INFN, Sez. di Milano); BINOSI, Daniele (ECT* Fondazione Bruno Kessler)

Presenter: QUADRI, Andrea (INFN, Sez. di Milano)

Session Classification: Thursday Afternoon B

Contribution ID: 22

Type: **not specified**

Analytic Two-Loop Five-Parton QCD Amplitudes from Numerical Unitarity

Tuesday, September 10, 2019 10:00 AM (25 minutes)

We present the analytic form of all two-loop five-parton helicity amplitudes required for the calculation of NNLO QCD corrections to the production of three jets at hadron colliders in the leading-color approximation. The results are analytically reconstructed from exact numerical evaluations over finite fields. We employ a number of physics-motivated ideas to facilitate the reconstruction, as well as an optimized approach to the numerical treatment of particle states in D dimensions. This allows to obtain the analytical expressions with a modest computational effort. Systematic simplification of the amplitudes using multivariate partial-fraction decomposition leads to a particularly compact form.

Primary authors: PAGE, Ben (IPhT CEA Saclay); FEBRES CORDERO, Fernando (University of Freiburg); ITA, Harald (Freiburg University); DORMANS, Jerry (University of Freiburg); ABREU, Samuel (CP3, UC Louvain); SOTNIKOV, Vasily (University of Freiburg)

Presenter: SOTNIKOV, Vasily (University of Freiburg)

Session Classification: Tuesday Morning A

Contribution ID: 23

Type: **not specified**

Heavy quark form factors at three loops

Wednesday, September 11, 2019 11:30 AM (25 minutes)

We present new results for heavy quark form factors at three loop order.

Primary author: MARQUARD, Peter (DESY)

Presenter: MARQUARD, Peter (DESY)

Session Classification: Wednesday Morning B

Contribution ID: 24

Type: **not specified**

Polarized and unpolarized heavy flavor corrections to DIS in 2- and 3-loop order-loop

Thursday, September 12, 2019 5:00 PM (25 minutes)

Recent results are presented on polarized and unpolarized heavy flavor corrections to DIS to 2- and 3-loop order in the full region and for large virtualities. In the polarized case we also discuss the treatment of γ_5 and derive results in the M-scheme.

Primary author: Prof. BLUEMLEIN, Johannes (DESY)

Presenter: Prof. BLUEMLEIN, Johannes (DESY)

Session Classification: Thursday Afternoon A

Contribution ID: 25

Type: **not specified**

Non-leptonic B-decays at two-loops in QCD Factorisation

Tuesday, September 10, 2019 3:30 PM (25 minutes)

I will present the calculation of and results for the two-loop penguin amplitudes appearing in non-leptonic B-decays in the framework of QCD Factorisation. I will discuss the details of the computation of this genuine two-loop, two-scale problem, focusing i) on the analytic computation of the master integrals and ii) on the (partially analytic) convolution of the hard kernel with the distribution amplitude of the light final-state meson. I will present phenomenological results, with the two-loop correction included, for branching ratios and direct CP-asymmetries of penguin-dominated non-leptonic B-decays.

Primary author: HUBER, Tobias (University of Siegen)

Presenter: HUBER, Tobias (University of Siegen)

Session Classification: Tuesday Afternoon A

Contribution ID: 26

Type: **not specified**

The $\mathcal{O}(\alpha^2)$ Initial State QED Corrections to $e^+ e^-$ Annihilation into a Neutral Vector Boson Revisited

Tuesday, September 10, 2019 6:00 PM (25 minutes)

At $e^+ e^-$ colliders the QED–initial state radiation forms a large part of the radiative corrections. Their precise and fast evaluation is an essential asset for the experiments at LEP, the ILC and the FCC-ee, operating at high luminosity. A long standing problem in the analytic understanding of the $\mathcal{O}(\alpha^2)$ initial state radiation is the observed discrepancy between the calculation of Berends et al. (1988) in the limit $m_e^2 \ll s$ and the result of the effective calculation using massive operator matrix elements by Blümlein et al. (2011) aiming directly for this limit. In order to resolve this important issue we recalculated this process by integrating directly over the phase space without any approximation. For parts of the corrections we find exact solutions of the cross section in terms of iterated integrals over square root valued letters representing incomplete elliptic integrals and iterations over them. The expansion in the limit $m_e^2 \ll s$ reveals errors in the constant $\mathcal{O}(\alpha^2)$ term of the former calculation and yields agreement with the calculation based on massive operator matrix elements, which has impact on the experimental analysis programs. This finding also explicitly proofs the factorization of massive initial state particles in the high energy limit at $\mathcal{O}(\alpha^2)$ for this process.

Primary authors: DE FREITAS, Abilio (DESY - Zeuthen); RAAB, Clemens (JKU Linz); BLUEMLEIN, Johannes (DESY); SCHÖNWALD, Kay (DESY)

Presenter: SCHÖNWALD, Kay (DESY)

Session Classification: Tuesday Afternoon B

Contribution ID: 27

Type: **not specified**

Hidden Analytic Structure of Two-Loop Higgs Amplitudes

Monday, September 9, 2019 11:00 AM (25 minutes)

The discovery of a standard-model-like Higgs boson at LHC set a milestone in particle physics. For probing potential new physics beyond the Standard Model as well as understanding the details of Higgs physics, the high precision computation of Higgs amplitudes is mandatory. We obtain the two-loop Higgs plus three-parton amplitudes with high dimension operators in Higgs effective field theory. While efficient new methods have been developed in the computation, a particular focus will be on the analytic structure of the results, which take remarkably simple form and show hidden relations. In particular, the results satisfy the so-called maximal transcendentality principle, which conjectures that QCD and N=4 SYM results share the same leading transcendental parts. The simplicity of the results and the surprising correspondence indicate there may be further hidden analytic structure to be uncovered which hopefully may lead to a better way in computation in practice. We will discuss the correspondence as well as the possible impact.

Primary author: Prof. YANG, Gang

Presenter: Prof. YANG, Gang

Session Classification: Monday Morning

Track Classification: F

Contribution ID: 28

Type: **not specified**

A refined machinery to calculate large moments from coupled systems of linear differential equations

Thursday, September 12, 2019 11:00 AM (25 minutes)

Recently, we have worked out how thousands of moments of Feynman integrals can be computed if they are represented by coupled systems of linear differential equations and sufficiently many initial values. Given these moments one is in the position to derive recurrence relations and to solve these recurrences, e.g., within the class of indefinite nested sums. In this talk we will present a refined version of this large moment method that speeds up the necessary calculation steps and that reduces the number of needed initial values. We show that this improved machinery can be used efficiently to calculate, e.g., contributions of the 3-loop massive form factor.

Primary author: SCHNEIDER, Carsten (RISC, Johannes Kepler University Linz)

Presenter: SCHNEIDER, Carsten (RISC, Johannes Kepler University Linz)

Session Classification: Thursday Morning A

Contribution ID: 29

Type: **not specified**

Binary Black Holes and Scattering Amplitudes

Friday, September 13, 2019 11:00 AM (25 minutes)

We combine tools from the modern amplitudes program and effective field theory to develop a systematic and scalable method for deriving classical dynamics for binary systems from on-shell scattering. Applying this to gravitationally interacting massive scalars yields the first derivation of the conservative Hamiltonian for compact spinless binaries at third post-Minkowskian order. The resulting Hamiltonian is in complete agreement with corresponding terms in state-of-the-art expressions at fourth post-Newtonian order as well as the probe limit at all orders in velocity. Prospects for improving the accuracy of theoretical waveform templates employed in gravitational wave detection are discussed.

Primary authors: ROTHSTEIN, Ira (CMU); CHEUNG, Clifford; BERN, Zvi (Univ. of California Los Angeles (US)); SOLON, Mikhail; ZENG, Mao (Stony Brook University); ROIBAN, Radu (Penn State University); SHEN, Chia-Hsien (UCLA)

Presenter: SOLON, Mikhail

Session Classification: Friday Morning

Contribution ID: 30

Type: **not specified**

A new formulation of the loop-tree duality at higher loops

Thursday, September 12, 2019 2:30 PM (25 minutes)

Relating loop integrals to tree level objects goes back several decades to Feynman. In the past ten years the loop-tree duality theorem was introduced, which expresses l -loop integrals in terms of phase space integrals of sum of trees obtained from cutting l internal propagators of the loop graph. In addition, the uncut propagators gain a modified $i\delta$ -prescription, named dual propagators.

In my talk I present a new formulation of the loop-tree duality theorem for higher loop diagrams valid both for massless and massive cases. In this new framework one can go beyond loop-graphs and calculate the integrand of loop-amplitudes as a weighted sum of tree graphs, which form a tree-like object. These objects can be computed efficiently via recurrence relations.

Primary authors: Dr SZŐR, Zoltán (Mainz University); WEINZIERL, Stefan (Universität Mainz); Mr VESGA, Juan-Pablo (Mainz University); Mr RUNKEL, Robert (Mainz University)

Presenter: Dr SZŐR, Zoltán (Mainz University)

Session Classification: Thursday Afternoon A

Track Classification: F

Contribution ID: 31

Type: **not specified**

Simple differential equations for Feynman integrals associated to elliptic curves

Monday, September 9, 2019 5:00 PM (25 minutes)

I will discuss Feynman integrals, which are associated to elliptic curves and their differential equations. I will show for non-trivial examples how the system of differential equations can be brought into an ε -form. Single-scale and multi-scale cases will be discussed.

Primary author: WEINZIERL, Stefan (Universität Mainz)

Presenter: WEINZIERL, Stefan (Universität Mainz)

Session Classification: Monday Afternoon

Contribution ID: 32

Type: **not specified**

Wilson-line geometries and the relation between IR singularities of form factors and the large-x limit of DGLAP splitting functions

Tuesday, September 10, 2019 3:00 PM (25 minutes)

We discuss the relation between the infrared singularities of on-shell partonic form factors and parton distribution functions (PDFs) near the elastic limit, through their factorisation in terms of Wilson-line correlators. Ultimately we identify the difference between the anomalous dimension controlling single poles of these two quantities to all loops in terms of the closed parallelogram Wilson loop. To arrive at this result we first use the common hard-collinear behaviour of the two to derive a relation between their respective non-collinear soft singularities, and then show that the latter is manifested in terms of differing Wilson-line geometries. We use explicit diagrammatic calculations in configuration space through two loops to verify the relation. More generally, the emerging picture allows us to classify collinear singularities in eikonal quantities depending on whether they are associated with finite (closed) Wilson-line segments or infinite (open) ones.

Primary authors: MILLOY, Calum (University of Edinburgh); GARDI, Einan; FALCIONI, Giulio

Presenter: MILLOY, Calum (University of Edinburgh)

Session Classification: Tuesday Afternoon B

Contribution ID: 34

Type: **not specified**

Planar Master Integrals for the two-loop light-fermions electroweak corrections to Higgs plus jet production

Thursday, September 12, 2019 9:30 AM (25 minutes)

In this talk, I will present the analytic calculation of the planar master integrals for the two-loop light-fermion electroweak corrections for the production of a Higgs boson in the gluon-gluon fusion channel. The complete dependence on the electroweak boson mass is retained. The master integrals are evaluated by means of the differential equations method and the analytic result are expressed in terms of multiple polylogarithms up to weight four.

The Higgs signals provide a strong test of the Standard Model and can be a probe of New Physics in case a deviation from the SM behavior of the Higgs properties will be revealed.

Primary authors: BONCIANI, Roberto (Dipartimento di Fisica); DEL DUCA, Vittorio (Universita e INFN Torino (IT)); CASCONI, Valerio (Università La Sapienza); Dr MORIELLO, Francesco (ETH Zurich, Institut für theoretische Physik); Dr BECCHETTI, Matteo (Center for Cosmology, Particle Physics and Phenomenology (CP3), Univerité Catholique de Louvain)

Presenter: CASCONI, Valerio (Università La Sapienza)

Session Classification: Thursday Morning A

Contribution ID: 35

Type: **not specified**

Matter dependence of the four-loop cusp anomalous dimension

Friday, September 13, 2019 10:00 AM (25 minutes)

The cusp anomalous dimension is a universal and ubiquitous quantity in QCD. It governs the IR structure of scattering amplitudes and is the key ingredient to (Sudakov) resummation for high-energy collider processes. I will report on recent analytic results on the matter dependence of the cusp anomalous dimension at four loops and discuss the calculational methods used to obtain them.

Primary author: STAHLHOFEN, Maximilian (JGU Mainz)

Presenter: STAHLHOFEN, Maximilian (JGU Mainz)

Session Classification: Friday Morning

Contribution ID: 36

Type: **not specified**

On $gg \rightarrow ZZ$ production at two loops with full top mass dependence

Thursday, September 12, 2019 2:30 PM (25 minutes)

In this talk, we discuss top quark contributions to ZZ production through gluon fusion at two loops. We use a syzygy based approach for the reductions to master integrals. In order to numerically evaluate the amplitude, we express it in terms of finite integrals, which we construct out of linear combinations of divergent integrals using a new algorithm.

Primary authors: AGARWAL, Bakul (Michigan State University); VON MANTEUFFEL, Andreas (Michigan State University)

Presenter: AGARWAL, Bakul (Michigan State University)

Session Classification: Thursday Afternoon B

Contribution ID: 37

Type: **not specified**

Master Integrals for the two-loop, non-planar QCD corrections to top-quark pair production in the quark-annihilation channel

Thursday, September 12, 2019 9:00 AM (25 minutes)

We present the analytic calculation of the Master Integrals for certain two-loop, non-planar topologies that enter the calculation of the amplitude for top-quark pair hadroproduction in the quark-annihilation channel. These Master Integrals are needed to complete the evaluation of the two color factors in the quark-annihilation channel which are not yet known analytically at two-loop. We compute the Master Integrals using the method of differential equations in canonical form. The solution is given as a series expansion in the dimensional regularisation parameter through to weight four, the expansion coefficients are given in terms of generalized harmonic polylogarithms of two dimensionless variables.

Primary authors: Dr BECCHETTI, Matteo (Center for Cosmology, Particle Physics and Phenomenology (CP3), Univeritè Catholique de Louvain); BONCIANI, Roberto; CASCONI, Valerio (Università La Sapienza); FERROGLIA, Andrea (New York City College of Technology CUNY); LAVACCA, Simone (University of Rome Sapienza); VON MANTEUFFEL, Andreas (Michigan State University)

Presenter: Dr BECCHETTI, Matteo (Center for Cosmology, Particle Physics and Phenomenology (CP3), Univeritè Catholique de Louvain)

Session Classification: Thursday Morning A

Contribution ID: 38

Type: **not specified**

Di-Higgs production in bottom quark annihilation at NNLO QCD

Tuesday, September 10, 2019 6:00 PM (25 minutes)

We present NNLO QCD corrections to production of pair of Higgs bosons in bottom quark annihilation at the Large Hadron Collider. We take into account all the partonic channels in five flavour scheme. We find that these corrections are important for the reliable predictions which are less sensitive to unphysical scales.

Primary authors: Prof. VAJRVELU, Ravindran (The Institute of Mathematical Sciences); Ms H.A, Ajjath; Ms MUKHERJEE, Pooja; Dr DAS, Goutam; Mr CHAKRABORTY, Amlan

Presenter: Prof. VAJRVELU, Ravindran (The Institute of Mathematical Sciences)

Session Classification: Tuesday Afternoon A

Contribution ID: 39

Type: **not specified**

Two loop QCD amplitudes for di-pseudoscalar Higgs production

Thursday, September 12, 2019 3:00 PM (25 minutes)

We compute the two-loop massless QCD corrections to the four point amplitude $g + g \rightarrow A + A$. Two operators contribute this amplitude and the ultraviolet renormalisation requires careful treatment involving mixing. The universal structure of the infrared poles are studied in detail.

Primary authors: BHATTACHARYA, Arunima; MATHEWS, Prakash; MAHAKHUD, Maguni; V, Ravindran

Presenter: MATHEWS, Prakash

Session Classification: Thursday Afternoon B

Contribution ID: 40

Type: **not specified**

N3LO predictions for the decay of the Higgs boson to bottom quarks

Friday, September 13, 2019 11:30 AM (25 minutes)

We present a fully-differential calculation of the $H \rightarrow b\bar{b}$ decay at next-to-next-to-next-to-leading order (N3LO) accuracy. Our calculation considers diagrams in which the Higgs boson couples directly to the bottom quarks. In order to regulate the infrared divergences present at this order we use the Projection-to-Born technique coupled with N-jettiness slicing. After validating our methodology at next-to-next-to-leading order (NNLO) we present exclusive jet rates and differential distributions for jet observables at N3LO accuracy using the Durham jet algorithm in the Higgs rest frame.

Primary authors: Mr MONDINI, Roberto (University at Buffalo); Mr SCHIAVI, Matthew (University at Buffalo); Dr WILLIAMS, Ciaran (University at Buffalo)

Presenter: Mr MONDINI, Roberto (University at Buffalo)

Session Classification: Friday Morning

Contribution ID: 41

Type: **not specified**

Elastic neutrino-electron scattering within the effective field theory approach

Wednesday, September 11, 2019 12:30 PM (25 minutes)

Elastic neutrino-electron scattering provides an important tool for normalizing neutrino flux in modern experiments. This process is subject to large radiative corrections. We determine the Fermi effective theory performing the one-loop matching to the Standard model at the electroweak scale with subsequent running down to GeV scale. Based on this theory, we analytically evaluate virtual corrections and distributions with one radiated photon beyond the electron energy spectrum. We discuss the relevance of radiative corrections depending on conditions of modern and future accelerator-based neutrino experiments.

Primary authors: Dr TOMALAK, Oleksandr (University of Kentucky); Prof. HILL, Richard (University of Kentucky & Fermilab)

Presenter: Dr TOMALAK, Oleksandr (University of Kentucky)

Session Classification: Wednesday Morning A

Contribution ID: 42

Type: **not specified**

Completing the four-body contributions to $\bar{B} \rightarrow X_s \gamma$ at NLO

Tuesday, September 10, 2019 3:00 PM (25 minutes)

The inclusive radiative $\bar{B} \rightarrow X_s \gamma$ decay constitutes an important pillar in the indirect search for new physics and allows to constrain the parameter space of many models.

In this talk we present the ongoing efforts in the computation of four-body contributions to the process $\bar{B} \rightarrow X_s \gamma$, namely those of $b \rightarrow s \bar{q} q \gamma$ at NLO in the strong coupling and the necessary complementing 5-particle cuts of the gluon-bremsstrahlung $b \rightarrow s \bar{q} q \gamma + g$.

Although these corrections are expected to be small, this computation formally completes the NLO contributions to $\bar{B} \rightarrow X_s \gamma$.

Since the anomalous dimensions are already computed to a sufficient order, the main tasks are the systematic generation of the 1-loop amplitude, the automation of the phase space integration, the infrared-regularization and finally the renormalization of the diagrams including the operator mixing.

The results obtained so far are shown and the further structure of the calculation is outlined.

Primary author: MOOS, Lars-Thorben

Presenter: MOOS, Lars-Thorben

Session Classification: Tuesday Afternoon A

Contribution ID: 43

Type: **not specified**

The Gravitational Potential of Two Point Masses at Five Loops

Wednesday, September 11, 2019 12:00 PM (25 minutes)

Higher-order corrections to the interaction potential between non-relativistic massive objects can be obtained systematically in a Post-Newtonian expansion in the small velocity and weak coupling. We present the calculation of these corrections up to five loops using techniques from multi-loop computations in high-energy physics.

Primary authors: BLUEMLEIN, Johannes (DESY); Dr MAIER, Andreas (DESY); MARQUARD, Peter (DESY)

Presenter: Dr MAIER, Andreas (DESY)

Session Classification: Wednesday Morning A

Contribution ID: 44

Type: **not specified**

Threshold effects at next-to-leading power

Tuesday, September 10, 2019 4:00 PM (25 minutes)

In QCD, soft radiation plays an important role in kinematic regions where resulting threshold logarithms become large. In this talk, I address such effects beyond leading power in the threshold expansion, for both fixed order and resummed results. For the double-real single-virtual correction to Drell-Yan, a large class of next-to-leading power (NLP) threshold logarithms is shown to be obtained using the method of regions [1]. For more general processes with a colour singlet final state, leading logarithms at NLP are resummed by dressing the shifted Born level cross section with exponentiated LP webs [2].

[1] N. Bahjat-Abbas, J. Sinninghe Damsté, L. Vernazza and C. D. White, “On next-to-leading power threshold corrections in Drell-Yan production at N³LO”, JHEP 10 (2018) 144, 1807.09246.

[2] N. Bahjat-Abbas, D. Bonocore, J. Sinninghe Damsté, E. Laenen, L. Magnea, L. Vernazza and C. D. White, “Diagrammatic resummation of leading-logarithmic threshold effects at next-to-leading power”, 1905.13710.

Primary authors: WHITE, Chris (Queen Mary University of London); BONOCORE, Domenico (Westfälische Wilhelms-Universität Münster); LAENEN, Eric (Nikhef National institute for subatomic physics (NL)); Mr SINNINGHE DAMSTÉ, Jort (University of Amsterdam); Dr VERNAZZA, Leonardo (Nikhef and University of Amsterdam); MAGNEA, Lorenzo (Universita e INFN (IT)); Ms BAHJAT-ABAS, Nadia (Queen Mary University London)

Presenter: Mr SINNINGHE DAMSTÉ, Jort (University of Amsterdam)

Session Classification: Tuesday Afternoon B

Contribution ID: 45

Type: **not specified**

Orbital dynamics from the double copy and effective field theory

Wednesday, September 11, 2019 11:30 AM (25 minutes)

We compute the third-post-Minkowskian conservative Hamiltonian of binary black holes using modern tools from scattering amplitudes and effective field theory. In the limit of large separation, non-spinning black holes have an effective description in terms scalar field particles coupled to gravity. The two-loop integrand is constructed using generalized unitarity and the double copy construction. We perform loop integration by expanding around zero velocity to high orders, using techniques borrowed from NRQCD, before matching the series to known functions. For some diagrams, we also validate the results using the method of differential equations. We comment on spurious collinear singularities that arise from the truncation of the quantum amplitude to the classical limit.

Primary author: ZENG, Mao (UC Los Angeles)

Co-authors: Prof. BERN, Zvi (UCLA); Prof. CHEUNG, Clifford (Caltech); ROIBAN, Radu (Penn State); Dr SHEN, Chia-Hsien (UCLA); Dr SOLON, Mikhail P. (Caltech)

Presenter: ZENG, Mao (UC Los Angeles)

Session Classification: Wednesday Morning A

Contribution ID: 46

Type: **not specified**

From sum-integrals to continuum integrals and back

Thursday, September 12, 2019 10:00 AM (25 minutes)

Within finite-temperature quantum field theory, the evaluation of vacuum-type sum-integrals plays a central role in the determination of equilibrium observables, such as the free energy (or pressure) of a thermal system.

As has been repeatedly observed in the past, many two-loop sum-integrals can be decomposed into one-loop factors, allowing for analytic solutions in the space-time dimension d .

In this talk, we sketch a recent proof that this decomposition is generic, and give an algorithm that constructs this decomposition for any massless bosonic two-loop vacuum sum-integral. A number of related insights into a special class of two-loop massive vacuum integrals are discussed along the way.

Primary author: SCHRÖDER, York (UBB Chillán)

Co-author: DAVYDYCHEV, Andrei

Presenter: SCHRÖDER, York (UBB Chillán)

Session Classification: Thursday Morning A

Contribution ID: 47

Type: **not specified**

Photon pair production in gluon fusion: Top quark threshold effects

Friday, September 13, 2019 12:00 PM (25 minutes)

We present a calculation of the NLO QCD corrections to the loop-induced production of a photon pair through gluon fusion, including massive top quarks at two loops, where the two-loop integrals are calculated numerically. Matching the results for the virtual amplitude to a threshold expansion, we obtain accurate results around the top quark pair production threshold. We analyse how the top quark threshold corrections affect distributions of the photon pair invariant mass and comment on the possibility to determine the top quark mass from precision measurements of the diphoton invariant mass spectrum.

Primary authors: HEINRICH, Gudrun; JAHN, Stephan; JONES, Stephen; YOKOYA, Hiroshi; SCHLENK, Johannes; KERNER, Matthias; CHEN, Long (Max Planck Institute for Physics)

Presenter: CHEN, Long (Max Planck Institute for Physics)

Session Classification: Friday Morning

Contribution ID: 48

Type: **not specified**

Threshold resummation at next-to-leading power

Wednesday, September 11, 2019 10:00 AM (25 minutes)

In this talk, I am going to report on the resummation of the leading logarithmic corrections for the Drell-Yan production and Higgs production in gluon fusion at the next-to-leading power in threshold expansion. I will describe how the kinematic power-corrections are accounted for and the structure of renormalisation group equations for the generalised soft function which appears after factorisation of the time-ordered products. These include power-suppressed terms in the SCET Lagrangian. The leading logarithmic solution of the RG equations will be presented, I will perform a comparison with known fixed order results, and comment on the impact for phenomenological studies.

Primary author: SZAFRON, Robert (TU München)

Co-authors: BENEKE, Martin (Technische Universitaet Muenchen (DE)); Mr JASKIEWICZ, Sebastian (Technical University of Munich); WANG, Jian; GARNY, Mathias (CERN); VERNAZZA, Leonardo (Nikhef and University of Amsterdam)

Presenter: SZAFRON, Robert (TU München)

Session Classification: Wednesday Morning B

Contribution ID: 49

Type: **not specified**

Fiducial differential cross sections at the LHC and their future applications

Tuesday, September 10, 2019 9:00 AM (25 minutes)

Fiducial differential cross sections are reliable observables that the LHC is providing more and more precise measurements. From the theory point of view, event generators could simulate the underlying processes and apply the same experimental selection criterion to reduce the systematic errors when comparing with data. I will introduce some of the implementations and simulations from NNLOJET package with the-state-of-the-art theory precisions at NNLO QCD and above then illustrate their future applications when comparing with LHC data.

Primary author: Dr CHEN, Xuan (Universitaet Zuerich (CH))

Co-authors: GEHRMANN, Thomas Kurt (Universitaet Zuerich (CH)); HUSS, Alexander Yohei (CERN); GLOVER, Nigel (Durham University)

Presenter: Dr CHEN, Xuan (Universitaet Zuerich (CH))

Session Classification: Tuesday Morning B

Contribution ID: 50

Type: **not specified**

Next-to-leading power factorization in threshold DY production

Thursday, September 12, 2019 10:00 AM (25 minutes)

Soft Collinear Effective Theory (SCET) formalism has been successfully applied to a number of important observables in collider physics improving the accuracy of fixed-order predictions via the leading power resummation of large logarithmic contributions which appear in certain regions of phase space. Recently, a renewed interest in subleading power corrections has arisen in the theoretical community. In this talk, I will discuss the framework for the threshold resummation of the Drell-Yan process and Higgs production via gluon fusion at next-to-leading power using SCET. I will prove the general factorisation formula and explain the new objects that emerge beyond leading power: collinear jet functions and generalized soft functions. The ingredients necessary to perform leading logarithmic resummation at next-to-leading power will be shown and I will present selected fixed order results.

Primary authors: BENEKE, Martin (Technische Universitaet Muenchen (DE)); Mr JASKIEWICZ, Sebastian (Technical University of Munich); VERNAZZA, Leonardo (Nikhef and University of Amsterdam); BROGGIO, Alessandro

Presenter: Mr JASKIEWICZ, Sebastian (Technical University of Munich)

Session Classification: Thursday Morning B

Contribution ID: 51

Type: **not specified**

Quark condensate and spectral density from renormalization group optimized perturbation

Thursday, September 12, 2019 5:30 PM (25 minutes)

Our renormalization group consistent version of optimized perturbation, RGOPT, had been used to calculate the nonperturbative QCD spectral density of the Dirac operator and the related chiral quark condensate $\langle \bar{q}q \rangle$, for $n_f = 2$ and $n_f = 3$ massless quarks. Sequences of approximations at two-, three-, and four-loop orders gave stable parameter-free determinations

$\langle \bar{q}q \rangle_{n_f=2}^{1/3}(2 \text{ GeV}) = -(0.833 - 0.845)\bar{\Lambda}_2$, and $\langle \bar{q}q \rangle_{n_f=3}^{1/3}(2 \text{ GeV}) = -(0.814 - 0.838)\bar{\Lambda}_3$, where the range is our estimated theoretical error and $\bar{\Lambda}_{n_f}$ the basic QCD scale in the \overline{MS} -scheme.

We update our previous analysis up to 5-loop order of (RG optimized) perturbation, thanks to the recently available five-loop order QCD renormalization group functions, and compare our results with other recent determinations from lattice simulations or other approaches.

Primary authors: KNEUR, Jean-Loic (Univ. Montpellier); NEVEU, André (Lab. Charles Coulomb)

Presenter: KNEUR, Jean-Loic (Univ. Montpellier)

Session Classification: Thursday Afternoon A

Contribution ID: 52

Type: **not specified**

Top-quark hadroproduction in NNLO QCD

Tuesday, September 10, 2019 9:30 AM (25 minutes)

The study of top-quark production and decay is central in the LHC physics programme, allowing precise tests of the Standard Model and offering a window on possible new physics. Accurate theoretical predictions are crucial for these analyses. In this talk, we report on a new calculation of the next-to-next-to-leading order QCD radiative corrections to the production of top-quark pairs at hadron colliders. The calculation is performed by using the qT-subtraction method to handle and cancel infrared singular contributions at intermediate stages of the computation, and represents its first complete application to the hadroproduction of a colourful high-mass system at next-to-next-to-leading order. We discuss the calculation of the additional soft contributions needed to implement qT subtraction for this process, and show first numerical results.

Primary authors: MAZZITELLI, Javier; GRAZZINI, Massimiliano (Universitaet Zuerich (CH)); DEVOTO, Simone (UZH); KALLWEIT, Stefan (Universita & INFN, Milano-Bicocca (IT)); CATANI, Stefano (Universita e INFN, Firenze (IT))

Presenter: DEVOTO, Simone (UZH)

Session Classification: Tuesday Morning B

Contribution ID: 53

Type: **not specified**

Soft-gluon effective coupling and cusp anomalous dimension

Monday, September 9, 2019 12:00 PM (25 minutes)

We consider the extension of the CMW soft-gluon effective coupling beyond the next-to-leading logarithmic accuracy. We present two proposals of a soft-gluon effective coupling that extend the CMW coupling to all perturbative orders. Although both effective couplings are well-defined in four dimensions, we examine their behaviour in $d=4-2\epsilon$ dimensions. We uncover an all-order perturbative relation with the cusp anomalous dimension: the (four dimensional) cusp anomalous dimension is equal to the d -dimensional soft-gluon effective coupling at the conformal point $\epsilon=\beta(\alpha_s)$, where the d -dimensional QCD beta-function, vanishes. We present the explicit expressions of the two soft-gluon couplings up to $O(\alpha_s^2)$ in d dimensions. In the four-dimensional case we compute the two soft couplings up to $O(\alpha_s^3)$. For one of the two couplings, we confirm the $O(\alpha_s^3)$ result previously presented by other authors. For the other coupling, we obtain the explicit relation with the cusp anomalous dimension up to $O(\alpha_s^4)$. We comment on Casimir scaling at $O(\alpha_s^4)$.

Primary author: GRAZZINI, Massimiliano (Universitaet Zuerich (CH))

Presenter: GRAZZINI, Massimiliano (Universitaet Zuerich (CH))

Session Classification: Monday Morning

Contribution ID: 54

Type: **not specified**

Diagrammatic Coaction of Two-Loop Feynman Integrals

Wednesday, September 11, 2019 9:30 AM (25 minutes)

It is known that one-loop Feynman integrals possess an algebraic structure encoding their analytic properties called the coaction, which can be written in terms of Feynman integrals and their cuts. This diagrammatic coaction, and the coaction on other classes of integrals such as hypergeometric functions, may be expressed using suitable bases of differential forms and integration contours. This provides a useful framework for computing coactions of Feynman integrals expressed using the hypergeometric functions. We will discuss recent developments in the calculation of two-loop diagrammatic coactions using this technique.

Primary author: MATTHEW, James (University of Edinburgh)

Presenter: MATTHEW, James (University of Edinburgh)

Session Classification: Wednesday Morning A

Contribution ID: 55

Type: **not specified**

CP even and odd Higgs boson production in electron-photon collisions

Thursday, September 12, 2019 12:00 PM (25 minutes)

Within the framework of the standard model as well as the two Higgs doublet model including the MSSM as a special case, we examine the CP-even and CP-odd Higgs boson production in electron-photon collisions. We particularly emphasize the role of the transition form factor in terms of which the production amplitudes can be given.

Primary author: UEMATSU , Tsuneo (Kyoto University)

Presenter: UEMATSU , Tsuneo (Kyoto University)

Session Classification: Thursday Morning B

Contribution ID: 56

Type: **not specified**

Rational terms in two-loop calculations

Tuesday, September 10, 2019 5:00 PM (25 minutes)

Recently, we published the OpenLoops 2 program, a powerful tool for the automation of NLO QCD and NLO EW calculations for all relevant LHC processes with high numerical stability in hard regions as well as in soft and collinear regions. This not only allows for highly efficient and accurate NLO calculations, but also for the numerically stable computation of NNLO real-virtual contributions.

In this talk we present first steps towards the automation of the numerical calculation of two-loop amplitudes with four-dimensional numerators. The new methods and results presented in this talk are expected to be published shortly before the conference.

Primary authors: ZOLLER, Max (UZH); POZZORINI, Stefano Augusto (Universitaet Zuerich (CH)); Mr ZHANG, Hantian (University of Zurich)

Presenter: ZOLLER, Max (UZH)

Session Classification: Tuesday Afternoon B

Contribution ID: 57

Type: **not specified**

Padé approach to top-quark mass effects in gluon fusion amplitudes

Thursday, September 12, 2019 11:30 AM (25 minutes)

Gluon fusion processes like single and double Higgs production exhibit slow convergence and pose severe computational challenges. We show how the top-quark mass dependence of the virtual amplitudes can be reconstructed with a conformal mapping and Padé approximants based on the expansion in the inverse top-quark mass and the non-analytic terms in the expansion around the top threshold. The method is then applied at two- and three-loop order.

Primary author: RAUH, Thomas Johannes Georg (Universität Bern)

Presenter: RAUH, Thomas Johannes Georg (Universität Bern)

Session Classification: Thursday Morning A

Contribution ID: 58

Type: **not specified**

Intersection Theory and Higgs Physics

Wednesday, September 11, 2019 10:00 AM (25 minutes)

When finding linear relations between Feynman integrals using integration-by-parts identities, a very large linear system has to be solved as an intermediate step.

This makes other approaches to the derivation of these identities a worthwhile pursuit. In this context, the concept of the intersection number is of interest, as it allows for the definition of (what amounts to) a scalar product between Feynman integrals, allowing the coefficients of the master integrals to be extracted using ordinary projections in the space of Feynman integrals.

Using this novel method, we will derive and discuss a number of identities between Feynman integrals relevant for Higgs physics.

Primary author: Dr FRELLESVIG, Hjalte Axel (University of Padova)

Co-authors: Prof. MASTROLIA, Pierpaolo (University of Padova); Dr LAPORTA, Stefano (University of Padova); Dr MANDAL, Manoj (University of Padova); Mr GASPAROTTO, Federico (University of Padova); Mr MATTIAZZI, Luca (University of Padova); Dr MIZERA, Sebastian (Perimeter institute)

Presenter: Dr FRELLESVIG, Hjalte Axel (University of Padova)

Session Classification: Wednesday Morning A

Contribution ID: 59

Type: **not specified**

NNLO mixed EW-QCD corrections to single vector boson production

Tuesday, September 10, 2019 10:00 AM (25 minutes)

In this talk, we outline the computational details to obtain mixed EW-QCD corrections to on-shell production of a single vector boson at the LHC at two-loop level. We use the novel method of differential equation to obtain the pure virtual, real-virtual and double-real master integrals.

Primary authors: VICINI, Alessandro; BUCCIONI, Federico (University of Zurich); Dr RANA, Narayan (INFN Milan); BONCIANI, Roberto (Universita di Roma La Sapienza)

Presenter: Dr RANA, Narayan (INFN Milan)

Session Classification: Tuesday Morning B

Track Classification: X

Contribution ID: 60

Type: **not specified**

Towards 2 -> 3 NNLO QCD calculations

Tuesday, September 10, 2019 12:00 PM (25 minutes)

Precise predictions for total and differential cross sections at hadron colliders became an important corner stone of the LHC physics. The lack of new 'smoking-gun' physics signals requires precise comparisons between measurements and Standard Model predictions to get a handle on new physics effects. Tremendous efforts have been made to push perturbative calculations to higher orders such that NNLO QCD calculations are now state-of-art for most $2 \rightarrow 1$ and $2 \rightarrow 2$ hard scattering processes. Upcoming five-point two-loop amplitudes and refined subtractions schemes for real radiation contributions allow first steps in the direction of $2 \rightarrow 3$ scattering processes. I present novel NNLO QCD results for $2 \rightarrow 3$ processes obtained with the Sector-improved Subtraction Scheme and their phenomenological application.

Primary authors: PONCELET, Rene (Cambridge University); Prof. CZAKON, Michal Wiktor (Rheinisch Westfaelische Tech. Hoch. (DE)); MITOV, Alexander (University of Cambridge (GB))

Presenter: PONCELET, Rene (Cambridge University)

Session Classification: Tuesday Morning A

Contribution ID: 61

Type: **not specified**

Systematic integration of higher loop gauge theory amplitudes in position space

Thursday, September 12, 2019 12:00 PM (25 minutes)

Recently, there have been remarkable advances concerning the systematic integration of higher loop Feynman amplitudes. A synthesis of differential equation and number theoretical methods can be employed to calculate position space Feynman amplitudes in the massless case. The combination of these two methods makes this approach very efficient, as an IBP reduction step can be bypassed. We will review on how these techniques were used by one of the authors to calculate the 7-loop beta function in ϕ^4 theory in $D=4$. Moreover, we will show how these methods can be extended to general even dimensions and illustrate a further extension to gauge theories.

Primary author: BORINSKY, Michael (Nikhef)

Co-author: SCHNETZ, Oliver (Friedrich-Alexander-Universität Erlangen-Nürnberg)

Presenter: BORINSKY, Michael (Nikhef)

Session Classification: Thursday Morning A

Contribution ID: 62

Type: **not specified**

Recent developments in q_T subtraction: EW corrections and power suppressed contributions

Tuesday, September 10, 2019 2:30 PM (25 minutes)

q_T subtraction represents a well established and successful formalism to deal with the computation of QCD radiative corrections up to NNLO (and beyond) for a large class of processes relevant at the LHC. We have explored the possibility to extend q_T subtraction to the computation of EW corrections with the (final) aim to develop a subtraction formalism suitable for the computation of mixed QCDXEW corrections. We present numerical results for the complete NLO EW corrections to the Drell-Yan production of a massive lepton pair.

Furthermore, we have investigated the structure of the power suppressed contributions at small- q_T in this process and present new analytical results on the effects of the soft radiation emitted off a charged massive final state.

Primary authors: BUONOCORE, Luca (INFN - National Institute for Nuclear Physics); GRAZZINI, Massimiliano (Universitaet Zuerich (CH)); TRAMONTANO, Francesco (Universita e sezione INFN di Napoli (IT))

Presenter: BUONOCORE, Luca (INFN - National Institute for Nuclear Physics)

Session Classification: Tuesday Afternoon A

Contribution ID: 63

Type: **not specified**

Violation of the Kluberg-Stern-Zuber theorem and operator mixing in SCET

Wednesday, September 11, 2019 9:30 AM (25 minutes)

A well-known result states that operators that vanish by the classical equation of motion do not mix into physical operators. The result guarantees that the S-matrix is invariant under large classes of field redefinitions. It is shown that (and why) the theorem is violated in soft-collinear effective theory beyond the leading power in the soft-collinear expansion. The mixing of eom operators into physical operators is computed at next-to-leading power (NLP), which completes the one-loop renormalization of NLP N-jet operators. It is explained how to deal with divergent collinear convolution integrals.

Primary authors: BENEKE, Martin (Technische Universitaet Muenchen (DE)); GARNY, Mathias (CERN); SZAFRON, Robert (TU München); WANG, Jian

Presenter: BENEKE, Martin (Technische Universitaet Muenchen (DE))

Session Classification: Wednesday Morning B

Contribution ID: 64

Type: **not specified**

Mixed EW-QCD two-loop corrections to Drell-Yan production

Tuesday, September 10, 2019 11:30 AM (25 minutes)

The Drell-Yan production of charged lepton pairs is one of the key processes measured at hadron colliders. The QCD corrections to the cross-section are known to order α_s^2 and electroweak corrections are known to order α . The next important step for a better theoretical understanding is the complete calculation of the mixed QCD-EW corrections of order $\alpha_s\alpha$. In this talk, I report on the first calculation of the virtual two-loop corrections of order $\alpha_s\alpha$ to the cross-section. The calculation is carried out analytically using tensor reduction, IBP relations and the method of differential equations. We validate a previous calculation of the subset of mixed QCD-QED corrections and show how the jet and soft functions of that reference can be used to subtract the infrared divergencies of the complete mixed QCD-electroweak virtual corrections.

Primary authors: VON MANTEUFFEL, Andreas (Michigan State University); HELLER, Matthias

Presenter: HELLER, Matthias

Session Classification: Tuesday Morning B

Track Classification: X

Contribution ID: 65

Type: **not specified**

Exploring the Higgs sector via Higgs boson pair production

Tuesday, September 10, 2019 5:30 PM (25 minutes)

We show how anomalous trilinear Higgs boson couplings, as well as other anomalous couplings in the Higgs sector, impact the shapes of distributions in Higgs boson pair production. In particular we discuss the interplay between higher order QCD corrections and effects from physics beyond the Standard Model, parametrized by Effective Field Theory. We present new methods, partly based on machine learning, to extract information about the underlying BSM parameter space from di-Higgs observables.

Primary author: HEINRICH, Gudrun (Max Planck Institute for Physics)

Presenter: HEINRICH, Gudrun (Max Planck Institute for Physics)

Session Classification: Tuesday Afternoon A

Contribution ID: 66

Type: **not specified**

Mixed QCD x QED Corrections to Drell-Yan Z Production

Tuesday, September 10, 2019 12:00 PM (25 minutes)

When computing perturbative corrections to a process QCD provides the phenomenologically most significant contribution. Nevertheless, because of the similar size of α_S^2 respect to α_{QED} , for a precision prediction one needs to consider electroweak corrections as well.

In this talk we show how one can obtain the mixed QCDxQED corrections from pure QCD NNLO corrections by means of an abelianization procedure. We show this by explicitly applying such procedure to the production of an on-shell Z boson in hadronic collisions. This way, we profit from a legacy 20-year-old NNLO calculation to extend the available knowledge up to complete QCD@QED NNLO order.

Primary author: FABRE, Ignacio (ICAS-UNSAM)

Presenter: FABRE, Ignacio (ICAS-UNSAM)

Session Classification: Tuesday Morning B

Contribution ID: 67

Type: **not specified**

Top-quark effects in diphoton production through gluon fusion at NLO in QCD

Thursday, September 12, 2019 11:00 AM (25 minutes)

At hadron colliders, the leading production mechanism for a pair of photons is from quark-anti-quark annihilation at the tree level. However, due to large gluon-gluon luminosity, the loop-induced process $gg \rightarrow \gamma\gamma$ provides a substantial contribution. In particular, the amplitudes mediated by the top quark become important at the $t\bar{t}$ threshold and above. In this letter we present the first complete computation of the next-to-leading order (NLO) corrections (up to α_s^3) to this process, including contributions from the top quark. These entail two-loop diagrams with massive propagators whose analytic expressions are unknown and have been evaluated numerically. We find that the NLO corrections to the top-quark induced terms are very large at low diphoton invariant mass $m(\gamma\gamma)$ and close to the $t\bar{t}$ threshold. The full result including five massless quarks and top quark contributions at NLO displays a much more pronounced change of slope in the $m(\gamma\gamma)$ distribution at $t\bar{t}$ threshold than at LO and an enhancement at high invariant mass with respect to the massless calculation.

Primary authors: ZHAO, Xiaoran; MALTONI, Fabio (Universite Catholique de Louvain (UCL) (BE)); Dr MANDAL, Manoj (University of Padova)

Presenter: ZHAO, Xiaoran

Session Classification: Thursday Morning B

Contribution ID: 68

Type: **not specified**

Calculating the static gravitational two-body potential to fifth post-Newtonian order with Feynman diagrams

Wednesday, September 11, 2019 11:00 AM (25 minutes)

The effective field theory approach to general relativity allows to apply techniques for computing Feynman diagrams used in high energy physics in order to calculate the gravitational two-body potential. In the talk I will discuss the first-time calculation of the static two-body potential to fifth post-Newtonian order. These results were achieved thanks to a manifest factorization property of Feynman diagrams. The talk is based on arXiv:1902.10571.

Primary author: STURM, Christian

Presenter: STURM, Christian

Session Classification: Wednesday Morning A

Contribution ID: 69

Type: **not specified**

Syzygies for no-numerator or no-dot relations between Feynman integrals

Tuesday, September 10, 2019 9:00 AM (25 minutes)

In this talk I will discuss new algorithmic approaches to reduce Feynman integrals. Syzygies derived in the Lee-Pomeransky and the Baikov representation allow to find linear relations, which avoid the introduction of either irreducible numerators or higher powers of propagators, respectively. The relevant syzygies can be calculated with linear algebra methods based on finite fields. These techniques have been applied to calculate quark and gluon form factors in four-loop QCD as well as multi-scale two-loop amplitudes.

Primary authors: AGARWAL, Bakul (Michigan State University); VON MANTEUFFEL, Andreas (Michigan State University); SCHABINGER, Robert

Presenter: VON MANTEUFFEL, Andreas (Michigan State University)

Session Classification: Tuesday Morning A

Contribution ID: 71

Type: **not specified**

Analytic multi-loop results using finite fields and dataflow graphs with FiniteFlow

Monday, September 9, 2019 5:30 PM (25 minutes)

I will describe FiniteFlow, a framework for defining and executing numerical algorithms over finite fields and reconstructing analytically multivariate rational functions. The framework employs computational graphs, known as dataflow graphs, to combine basic building blocks into complex algorithms. This allows to easily implement a wide range of methods over finite fields in high-level languages and computer algebra systems, without being concerned with the low-level details of the numerical implementation. This approach sidesteps the appearance of large intermediate expressions and can be massively parallelized. I will show recent applications of this framework, such as analytic results for two-loop five-point scattering and for the four-loop cusp anomalous dimension.

Primary author: PERARO, Tiziano

Presenter: PERARO, Tiziano

Session Classification: Monday Afternoon

Contribution ID: 72

Type: **not specified**

Quark and gluon jet functions at 3-loops in QCD

Monday, September 9, 2019 6:30 PM (25 minutes)

I will talk about the recent computation of three loop jet functions (arXiv:1805.02637) in perturbative QCD. These results have been extracted from the known three loop coefficient functions for deep-inelastic scattering via the exchange of a virtual photon that couples to quarks or a scalar that couples to gluons and employing renormalization group invariance and factorization theorem. We obtain both the quark and the gluon jet functions up to three loop level. These jet functions being universal ingredients in the SCET framework, will play an important role in the phenomenological studies at the LHC, such as resummation of jet observables and also in subtraction methods.

Primary author: Dr DHANI, Prasanna K. (INFN, Florence)

Co-authors: Dr BANERJEE, Pulak (PSI, Villigen); Prof. RAVINDRAN, V. (IMSc, India)

Presenter: Dr DHANI, Prasanna K. (INFN, Florence)

Session Classification: Monday Afternoon

Contribution ID: 73

Type: **not specified**

Factorisation and resummation for double differential cross-section in τ_1 and τ_0

Thursday, September 12, 2019 9:30 AM (25 minutes)

We present a factorisation formula for the double differential cross-section in the N-jettiness variables τ_1 and τ_0 . The phase space spanned by these two variables are already known in different hierarchies between them. However the region $\tau_1 \sim \tau_0$ is not well known due to absence of a proper factorisation formula in this scenario. This region corresponds to two unordered but resolved emissions. We present the factorisation formula first time for such unordered emissions. We use Soft collinear Effective theory (SCET) to separate the soft and collinear modes contribution at the measurement level. Using the power counting argument in SCET, we completely separate the collinear and soft contribution which are encoded inside Beam and Soft functions respectively. We also comment on the structure of these objects as well as on their consistencies. Finally we describe the resummation and matching with other regions of phase space in particular the SCET⁺ region with strongly ordered emissions. This has immediate application on the improvement of parton shower accuracy in Geneva framework at NNLL['] accuracy as well as on the jet substructure observables without hierarchies.

Primary authors: Prof. TACKMANN, Frank (Deutsches Elektronen-Synchrotron (DE)); Dr DAS, Goutam (DESY); Dr SCHUNK, Lais Sarem (DESY)

Presenter: Dr DAS, Goutam (DESY)

Session Classification: Thursday Morning B

Contribution ID: 74

Type: **not specified**

Two-Loop QCD Helicity Amplitudes for Higgs Production Associated with a Vector Boson through Bottom Quark Annihilation

Thursday, September 12, 2019 3:30 PM (25 minutes)

Productions of the Higgs boson in association with a massive vector boson, i.e. the VH events, play an important role in the explorations of Higgs physics at the LHC, both for a precise study of Higgs' Standard Model couplings and for probing new physics. In this talk, we present the 2-loop massless QCD corrections to the helicity amplitudes of the associated Higgs production through the bottom quark-antiquark annihilation, which is a necessary ingredient to the full NNLO QCD corrections to this process in the 5-flavor (PDF) schemes. The computation is performed by projecting the 2-loop amplitudes onto an appropriate set of Lorentz structures, sufficient for deriving all physical helicity amplitudes, whose availability would later allow us to combine the VH production with the subsequent decay of the massive vector boson with full spin correlations accounted. The axial contributions are computed using Larin's prescription of the axial vertex (or γ_5), and the chiral Ward identities (or anomaly equations) of axial currents are verified. We provide the analytic expressions of the finite remainders of each helicity amplitudes in terms of polylogarithms of maximum weight four.

Primary authors: Dr AHMED, Taushif (Max-Planck-Institut für Physik); A. H., Ajjath (The Institute of Mathematical Sciences); Dr CHEN, Long (Max Planck Institute for Physics); Dr DHANI, Prasanna K. (INFN, Florence); MUKHERJEE, Pooja (The Institute of Mathematical Sciences); Prof. RAVINDRAN, V. (The Institute of Mathematical Sciences)

Presenter: Dr AHMED, Taushif (Max-Planck-Institut für Physik)

Session Classification: Thursday Afternoon B

Contribution ID: 75

Type: **not specified**

Mixed EW-QCD corrections to the higgs decay into bottom quarks

Tuesday, September 10, 2019 11:00 AM (25 minutes)

After the discovery of the Higgs boson the precise determination of its properties has become a priority. These precision studies often involve the decay of the Higgs boson to bottom quarks, since it is the predominately decay channel. In this talk I will present the calculation of the exact mixed EW-QCD corrections to this decay, which improves upon the existing approximate calculation. In particular I will elaborate on the treatment of γ_5 , the calculation of the exact master integrals and the renormalization procedure. I will conclude by presenting how this inclusive calculation could be extended to differential observables.

Primary authors: SCHUBERT, Ulrich; WILLIAMS, Ciaran (SUNY Buffalo); SCHIAVI, Matthew Marc (State University of New York at buffalo (US))

Presenter: SCHUBERT, Ulrich

Session Classification: Tuesday Morning B

Track Classification: X

Contribution ID: 76

Type: **not specified**

Decomposition of Feynman Integrals on the Maximal Cut by Intersection Numbers

Wednesday, September 11, 2019 9:00 AM (25 minutes)

The reduction of a large number of scalar multi-loop integrals to the smaller set of Master Integrals is an integral part of the computation of any multi-loop amplitudes. The reduction is usually achieved by employing the traditional Integral-By-Parts (IBP) relations. However, in case of integrals with large number of scales, this quickly becomes a bottleneck. In this talk, I will show the application of the recent idea, connecting the direct decomposition of Feynman integrals with the Intersection theory. Specifically, we will consider few maximally cut Feynman integrals relevant for di-photon production on maximal cut and show their direct decomposition to Master Integrals.

Primary authors: Mr GASPAROTTO, Federico (University of Padova); FRELLESVIG, Hjalte (NCSR Demokritos); Mr MATTIAZZI, Luca (University of Padova); KUMAR MANDAL, Manoj; Prof. MASTROLIA, Pierpaolo (University of Padova); Dr MIZERA, Sebastian (Perimeter institute); Dr LAPORTA, Stefano (University of Padova)

Presenter: KUMAR MANDAL, Manoj

Session Classification: Wednesday Morning A

Contribution ID: 77

Type: **not specified**

NNLO local analytic subtraction for final state radiation (and beyond)

Monday, September 9, 2019 3:30 PM (25 minutes)

I present the complete results of “Torino” local analytic subtraction of infrared divergences from final state real radiation at NNLO in QCD and report the progresses for the analogous treatment of the radiation from the initial state.

Primary authors: UCCIRATI, Sandro (INFN - National Institute for Nuclear Physics); MAGNEA, Lorenzo (Universita e INFN (IT)); TORRIELLI, Paolo (Universita e INFN Torino (IT)); MAINA, Ezio (Universita e INFN Torino (IT)); PELLICCIOLI, Giovanni (University of Torino); SIGNORILE-SIGNORILE, Chiara (Università degli Studi di Torino)

Presenter: UCCIRATI, Sandro (INFN - National Institute for Nuclear Physics)

Session Classification: Monday Afternoon

Contribution ID: 78

Type: **not specified**

Second order QCD corrections to the $g + g \rightarrow H + H$ four-point amplitude

Thursday, September 12, 2019 4:00 PM (25 minutes)

In this talk, I present the computation of the two loop massless QCD corrections to the four-point amplitude $g + g \rightarrow H + H$ (arXiv:1809.05388) resulting from effective operator insertions that describe the interaction of a Higgs boson with gluons in the infinite top quark mass limit. This amplitude is an essential ingredient to the third-order QCD corrections to Higgs boson pair production. Our results are implemented in a numerical code that can be used for further phenomenological studies.

Primary author: BANERJEE, Pulak (Paul Scherrer Institut)

Co-authors: BOROWKA, Sophia (CERN); DHANI, Prasanna K. (INFN, Florence); GEHRMANN, Thomas (Physik-Institut, Universität Zürich); RAVINDRAN, V (The Institute of Mathematical Sciences)

Presenter: BANERJEE, Pulak (Paul Scherrer Institut)

Session Classification: Thursday Afternoon B

Contribution ID: 79

Type: **not specified**

Infrared structure of N=4 SYM and Leading transcendentality principle in gauge theory

Tuesday, September 10, 2019 11:30 AM (25 minutes)

In this talk, we present a detailed study on the infrared structure of N=4 SYM and its connection to QCD. Calculation of collinear splitting functions helps to understand the structure and thus one can get infrared safe cross sections. We also demonstrate the factorization property that soft plus virtual part of the cross section satisfies and through factorization, we calculate soft distribution function up to third order in perturbation theory. We show that the soft distribution function is process independent that includes operators as well as external legs unlike QCD. In addition to this we analyse our findings against the known results in QCD through principle of maximum transcendentality and we extend our analysis further for the case of three point form factors involving several gauge invariant operators.

Primary authors: Mr CHAKRABORTY, Amlan (The Institute of Mathematical Sciences, HBNI, Taramani, Chennai-600113, India); Dr DHANI, Prasanna K (INFN, Sezione di Firenze, I-50019 Sesto Fiorentino, Florence, Italy); Dr BANERJEE, Pulak (Paul Scherrer Institut, Forschungsstrasse 111, CH-5232 Villigen PSI, Switzerland); Prof. RAVINDRAN, Vajravelu (The Institute of Mathematical Sciences, HBNI, Taramani, Chennai 600113, India); Dr AHMED, Taushif (Max-Planck-Institut für Physik, Werner-Heisenberg-Institut, 80805 München, Germany); Dr SETH, Satyajit (Institute for Particle Physics Phenomenology, Department of Physics, University of Durham, Durham, DH1 3LE, UK)

Presenter: Mr CHAKRABORTY, Amlan (The Institute of Mathematical Sciences, HBNI, Taramani, Chennai-600113, India)

Session Classification: Tuesday Morning A

Contribution ID: 80

Type: **not specified**

Loops from trees in four space-time dimensions

Thursday, September 12, 2019 3:00 PM (25 minutes)

In order to make predictions that can be compared with the results that the LHC delivers, there are several approaches to compare the experiment with the theory. It is known that to establish this comparison, we cannot rely on leading order (LO) calculations only. Hence, we need to consider next-to-leading order (NLO) contributions, that are often understood as virtual and real. Although we know how to generate these contributions, their evaluation is not always straightforward. In particular, because of the presence of infinities, UV and IR singularities. In this talk, we elaborate on their local cancellation by means of the four-dimensional unsubtraction scheme, which stems from the loop-tree duality theorem. To illustrate this method, we show the decay of $H \rightarrow \gamma\gamma$ at LO and NLO, for which, after properly cancelling the infinities at integrand level, by performing local UV renormalisation and local IR cancellation, we are allowed to integrate in four-dimensions. Finally, we analyse the singular structure of scattering amplitudes directly in the loop momentum space, which is particularly interesting to characterise unitarity and anomalous thresholds for specific kinematical configurations.

Primary author: Dr TORRES BOBADILLA, William Javier (IFIC CSIC-UV)

Presenter: Dr TORRES BOBADILLA, William Javier (IFIC CSIC-UV)

Session Classification: Thursday Afternoon A

Contribution ID: 81

Type: **not specified**

Generalized hypergeometric functions and intersection theory for Feynman integrals

Friday, September 13, 2019 9:00 AM (25 minutes)

Feynman integrals that have been evaluated in dimensional regularization can be written in terms of generalized hypergeometric functions. It is well known that properties of these functions are revealed in the framework of intersection theory. We propose further applications of intersection theory in the case of functions associated to positive geometries, in particular to construct a mathematical coaction, which has played an important role in recent progress in physical calculations.

Primary author: BRITTO, Ruth (Trinity College Dublin)

Presenter: BRITTO, Ruth (Trinity College Dublin)

Session Classification: Friday Morning

Contribution ID: 82

Type: **not specified**

The High-Energy Limit of 2 to 2 Partonic Scattering Amplitudes

Monday, September 9, 2019 11:30 AM (25 minutes)

Recently, there has been significant progress in computing scattering amplitudes in the high-energy limit using rapidity evolution equations. I describe the state-of-the-art and demonstrate the interplay between exponentiation of high-energy logarithms and that of infrared singularities. The focus in this talk is the imaginary part of 2 to 2 partonic amplitudes, which can be determined by solving the BFKL equation. I demonstrate that the wavefunction is infrared finite, and that its evolution closes in the soft approximation. Within this approximation I derive a closed-form solution for the amplitude in dimensional regularization, which fixes the soft anomalous dimension to all orders at NLL accuracy.

I then turn to finite contributions of the amplitude and show that the remaining ‘hard’ contributions can be determined algorithmically, by iteratively solving the BFKL equation in exactly two dimensions within the class of single-valued harmonic polylogarithms.

To conclude I present numerical results and analyse large-order behaviour of the amplitude.

Primary authors: CARON-HUOT, Simon; VERNAZZA, Leonardo (Nikhef and University of Amsterdam); Dr REICHEL, Joscha (University of Edinburgh); GARDI, Einan (The University of Edinburgh)

Presenter: GARDI, Einan (The University of Edinburgh)

Session Classification: Monday Morning

Contribution ID: 83

Type: **not specified**

Top mass effects in HJ and HH production

Wednesday, September 11, 2019 12:30 PM (25 minutes)

I will present NLO corrections to Higgs boson production in association with a jet, retaining the full dependence on the top quark mass. Details of the calculation will be presented, focusing on the evaluation of the two-loop integrals, which is done numerically with the program SedDec. In particular I will present various improvements to the code, which have been achieved since the first publication of the results, resulting in an improved stability and reduced run time of the program.

Primary author: KERNER, Matthias (University of Zürich)

Presenter: KERNER, Matthias (University of Zürich)

Session Classification: Wednesday Morning B

Contribution ID: 84

Type: **not specified**

Probing the scalar potential via double Higgs boson production at hadron colliders

Tuesday, September 10, 2019 5:00 PM (25 minutes)

Independent Measurements of Higgs self-couplings are crucial to probe new physics effects in the Higgs sector. Gluon fusion is the dominant mode for double Higgs production at hadron colliders. At leading order it is sensitive to the trilinear Higgs self-coupling. At higher orders in electroweak theory, it also becomes sensitive to the quartic coupling. We present a sensitivity study on the cubic and quartic self couplings in double Higgs production. Considering the relevant operators in the Standard Model Effective Field Theory up to dimension eight, we calculate the dominant contributions up to two-loop level.

Primary author: Dr SHIVAJI, Ambresh (IISER Mohali)

Presenter: Dr SHIVAJI, Ambresh (IISER Mohali)

Session Classification: Tuesday Afternoon A

Contribution ID: 85

Type: **not specified**

Soft gluon resummation for the associated top-pair quark production at the LHC

Tuesday, September 10, 2019 2:30 PM (25 minutes)

The studies of the associated production processes of a top-quark pair with a colour-singlet boson, e.g. Higgs, W or Z, are among the highest priorities of the LHC programme. Correspondingly, improvements in precision of theoretical predictions for these processes are of central importance. In this talk, we review the latest results on resummation of soft gluon corrections. The resummation is carried out using the direct QCD Mellin space technique in three-particle invariant mass kinematics. We discuss the impact of the soft gluon corrections on the predictions for the total cross sections and the differential distributions as well as compare the results with the recent measurements by ATLAS and CMS.

Primary authors: MOTYKA, Leszek; THEEUWES, Vincent; STEBEL, Tomasz; SCHWARTLÄNDER, Daniel; KULESZA, Anna

Presenter: KULESZA, Anna

Session Classification: Tuesday Afternoon B

Contribution ID: 86

Type: **not specified**

Heavy meson hadroproduction:open issues

Thursday, September 12, 2019 6:00 PM (25 minutes)

In this talk I will present open issues in the deacription of processes leading to the hadroproduction of at least one heavy meson or baryon, considering different flavour number schemes. Solving these issues is important for improving the accuracy of PDF fits and of predictions in high-energy astroparticle physics.

Primary author: GARZELLI, Maria Vittoria (Universita e INFN, Firenze (IT))

Presenter: GARZELLI, Maria Vittoria (Universita e INFN, Firenze (IT))

Session Classification: Thursday Afternoon A

Contribution ID: 87

Type: **not specified**

The role of soft quarks in next-to-leading power threshold effects

Tuesday, September 10, 2019 3:30 PM (25 minutes)

Cross-sections in perturbative QCD are plagued by large corrections from soft and collinear radiation. The most singular terms are known to be universal, which allows their resummation to all orders in the coupling. In our work, we have examined the structure of the next-to-singular contributions, which can originate from the emission of both soft quarks and gluons. In this talk, I will show that we can derive a next-to-soft amplitude for both types of emissions. In addition, I will show the numerical impact of these contributions on the transverse momentum distribution of the single-photon production process.

Primary authors: VAN BEEKVELD, Melissa (R); WHITE, Chris (Queen Mary University of London); LAENEN, Eric (Nikhef National institute for subatomic physics (NL))

Presenter: VAN BEEKVELD, Melissa (R)

Session Classification: Tuesday Afternoon B

Contribution ID: 88

Type: **not specified**

Five-Point Two-Loop Amplitudes Beyond the Planar Limit

Monday, September 9, 2019 2:30 PM (25 minutes)

Scattering amplitudes in supersymmetric theories are known to display many remarkable structures, but most higher loop results are limited to planar theories. In this talk we discuss the structure of the recent, symbol-level, results for the $N=4$ SYM amplitude with full colour dependence and the $N=8$ SUGRA amplitude. We elaborate on the modern, ansatz-based, approach to the calculation. Leading singularities in both 4 and d -dimensions are used to construct a set of rational prefactors upon which the amplitudes are numerically decomposed using finite-field arithmetic.

Primary author: PAGE, Ben (IPhT, CEA-Saclay)

Presenter: PAGE, Ben (IPhT, CEA-Saclay)

Session Classification: Monday Afternoon

Contribution ID: 89

Type: **not specified**

Precision Event Shapes at the LHC: the Transverse Energy-Energy Correlator in the Back-to-Back Limit

Monday, September 9, 2019 3:00 PM (25 minutes)

We present an operator based factorization formula for the transverse energy-energy correlator (TEEC) hadron collider event shape in the back-to-back (dijet) limit. This factorization formula exhibits a remarkably symmetric form, being a projection onto a scattering plane of a more standard transverse momentum dependent factorization. Soft radiation is incorporated through a dijet soft function, which can be elegantly obtained to next-to-next-to-leading order (NNLO) due to the symmetries of the problem. We present numerical results for the TEEC resummed to next-to-next-to-leading logarithm (NNLL) matched to fixed order at the LHC. Our results constitute the first NNLL resummation for a dijet event shape observable at a hadron collider, and the first analytic result for a hadron collider dijet soft function at NNLO. We anticipate that the theoretical simplicity of the TEEC observable will make it indispensable for precision studies of QCD at the LHC, and as a playground for theoretical studies of factorization and its violation.

Primary author: Prof. ZHU, HuaXing**Presenter:** Prof. ZHU, HuaXing**Session Classification:** Monday Afternoon

Contribution ID: **96**

Type: **not specified**

Welcome

Monday, September 9, 2019 9:00 AM (15 minutes)

Primary author: THE ORGANIZERS

Presenter: THE ORGANIZERS

Session Classification: Monday Morning

Contribution ID: 98

Type: **not specified**

The four-loop slope of the Dirac form factor

Friday, September 13, 2019 12:30 PM (25 minutes)

In this talk I will show the result of the 1100-digits calculation of the 4-loop QED contribution to the first derivative of the Dirac form factor at zero momentum transfer. An analytical fit has been obtained, and I will describe its structure. I will discuss also the contribution of this result to the Lamb shift of hydrogen.

Primary author: Dr LAPORTA, Stefano (University of Padova)

Presenter: Dr LAPORTA, Stefano (University of Padova)

Session Classification: Friday Morning

Contribution ID: 99

Type: **not specified**

The two-loop five-gluon all-plus helicity amplitude

Monday, September 9, 2019 6:00 PM (25 minutes)

As the experimental precision at the LHC keeps improving, next-to-next-to leading order (NNLO) corrections for scattering processes have become crucial for providing theoretical predictions of comparable accuracy. At present, only observables involving up to four particles are available at this order. The main bottleneck towards higher multiplicity observables is the analytic calculation of the required two-loop scattering amplitudes. I present the first fully analytic result for a full-color two-loop five-particle amplitude: the five-gluon amplitude in the all-plus helicity configuration. In order to achieve it, we analytically calculated all master integrals that describe the NNLO virtual corrections for the three-jet production. We express the amplitude in a remarkably compact form containing only logarithms, dilogarithms, and rational functions.

Primary author: Dr CHICHERIN, Dmitry (Max Planck Institute for Physics)

Presenter: Dr CHICHERIN, Dmitry (Max Planck Institute for Physics)

Session Classification: Monday Afternoon

Contribution ID: **100**

Type: **not specified**

International Advisory Board meeting

Thursday, September 12, 2019 6:30 PM (1h 30m)

Contribution ID: **101**

Type: **not specified**

Precision measurements at the LHC

Monday, September 9, 2019 9:15 AM (45 minutes)

This talk reviews experimental results of the ATLAS and CMS collaborations at the LHC, comprising SM, Top and Higgs measurements

Primary author: AMOROSO, Simone (Deutsches Elektronen-Synchrotron (DE))

Presenter: AMOROSO, Simone (Deutsches Elektronen-Synchrotron (DE))

Session Classification: Monday Morning

Contribution ID: **102**

Type: **not specified**

International Advisory Board meeting