

ALLEGATO A

UNIVERSITÀ DEGLI STUDI DI MILANO

Procedura di selezione per la chiamata a professore di II fascia da ricoprire ai sensi dell'art. 18, commi 1 e 4, della Legge n. 240/2010 per il settore concorsuale 02/A2 - Fisica Teorica delle Interazioni Fondamentali (settore scientifico-disciplinare FIS/02 - Fisica Teorica Modelli e Metodi Matematici) presso il Dipartimento di Fisica "Aldo Pontremoli", (avviso bando pubblicato sulla G.U. n. 68 del 01/09/2020) - Codice concorso 4415

Raoul Röntsch **CURRICULUM VITAE**

INFORMAZIONI PERSONALI (NON INSERIRE INDIRIZZO PRIVATO E TELEFONO FISSO O CELLULARE)

COGNOME	RÖNTSCH
NOME	RAOUL
DATA DI NASCITA	5 NOVEMBER 1984

CURRENT POSITION

1 October 2018 – present

Fellow
Department of Theoretical Physics
CERN
Geneva, Switzerland

PREVIOUS RESEARCH POSITIONS

1 October 2015 – 30 September 2018

Postdoctoral researcher
Institute for Theoretical Particle Physics
Karlsruhe Institute of Technology
Karlsruhe, Germany

24 September 2012 – 23 September 2015

Postdoctoral Research Associate
Theory Group
Fermi National Accelerator Laboratory
Batavia, Illinois, USA

EDUCATION

- 2013 D.Phil. In Theoretical Physics University of Oxford
Oxford, United Kingdom
Thesis title: *Higher order QCD corrections to diboson production at hadron colliders*
Supervisors: Prof. Giulia Zanderighi and Prof. Graham Ross
- 2008 M.Sc. In Theoretical Physics University of Cape Town
Cape Town, South Africa
Thesis title: *Up, Down and Strange Quark Masses from Finite Energy QCD Sum Rules*
Supervisors: Prof. Cesareo Dominguez and Prof. Raoul Viollier
- 2006 B.Sc. (Hons.) in Theoretical Physics (First Class*) University of Cape Town
Cape Town, South Africa
- 2005 B.Sc. (distinction*) in Applied Mathematics (distinction*) and Physics (distinction*) University of Cape Town
Cape Town, South Africa

*) Highest category for this degree.

NOTABLE AWARDS AT UNIVERSITY

- 2008 Rhodes Scholarship
The Rhodes Scholarship is the oldest international scholarship program, covering tuition and living costs for postgraduate study at the University of Oxford.

SCIENTIFIC METRICS

- **25** published papers in peer-reviewed journals
- **1** paper submitted to journal and awaiting peer review
- **5** conference proceedings
- Total citations: **1625**
- Citations per paper: **65**
- h-index: **19**

Metrics according to profile on INSPIRE, the most commonly-used literature database in high energy physics (accessed 15 September 2020). Metrics refer to publications in peer-reviewed journals only.

ABILITAZIONE SCIENTIFICA NAZIONALE

Settore Concorsuale 02/A2 – Fisica Teorica Delle Interazioni Fondamentali (fascia II)
Valido dal 07/01/2020 al 07/01/2029

Reviewers' reports:

“Il candidato all'Abilitazione Scientifica Nazionale RAOUL HORST RONTSCH ha ottenuto una valutazione positiva relativamente all'impatto della produzione scientifica (titolo di cui al numero 1 dell'Allegato A del decreto MIUR n.120, del 7 giugno 2016) raggiungendo almeno due valori soglia su tre. Inoltre il candidato è risultato essere in possesso di almeno tre titoli fra quelli precedentemente elencati dalla Commissione Concorsuale, secondo quanto previsto al comma 2 dell'articolo 5 dello stesso decreto. Il candidato presenta inoltre, ai sensi dell'articolo 7, pubblicazioni scientifiche che la Commissione, assorbendo ed integrando in questo giudizio

collettivo le osservazioni contenute nei giudizi individuali, valuta positivamente secondo tutti i criteri elencati nell'articolo 4, e giudica complessivamente di elevata qualità. La Commissione ritiene quindi all'unanimità che, per qualità e originalità dei risultati scientifici, e per il riconoscimento ottenuto nella comunità di ricerca di riferimento del settore concorsuale, il candidato abbia raggiunto la maturità scientifica in relazione al settore concorsuale 02A2. Pertanto, ai sensi dell'art. 3 del decreto MIUR n.120, del 7 giugno 2016, la Commissione Nazionale di Abilitazione, settore 02A2, attribuisce unanime l'abilitazione ad esercitare le funzioni di professore universitario di seconda fascia al candidato RAOUL HORST RONTSCH.”

TEACHING

- 2015 – 2017 Teaching assistant to Prof. Kirill Melnikov
Karlsruhe Institute of Technology, Germany
Courses taught: Introductory quantum field theory, advanced quantum field theory, effective field theories, theory of strong interactions
Responsibilities: I was responsible for devising exercise problems, and conducting exercise classes and tutorial sessions with the students.
- 2011 – 2012 Stipendiary Lecturer
Part-time position at Trinity College, University of Oxford, United Kingdom
Courses taught: Introductory mathematical methods for physicists, atomic and subatomic physics
Responsibilities: I conducted weekly tutorial meetings with small groups of 2 or 3 students, during which I would elaborate on the material covered in the lectures and work through the solutions to the weekly exercises. These tutorials form an integral part of the Oxford undergraduate curriculum, and allow the students to receive individual attention from the tutor, who is typically a member of faculty. I therefore had more teaching responsibilities than normal for a graduate student, and a teaching load approximately the same as that of a junior faculty member. I also had some administrative responsibilities, including assisting in the undergraduate admissions interviews.
- 2009-2011 Course Tutor
Part-time position in Department of Physics, University of Oxford, United Kingdom
Course taught: Introductory quantum field theory
Responsibilities: I was responsible for conducting a weekly exercise class.
- 2006 – 2008 Course Tutor
Part-time position in Department of Physics, University of Cape Town, South Africa
Courses taught: Introductory mechanics, introductory electromagnetism
Responsibilities: I conducted weekly exercise and tutorial classes reviewing material covered in lectures and going through exercise sheets. This course was within a program designed for students from previously disadvantaged areas whose high school education had not adequately prepared them for university, and who therefore needed additional support in completing their degree.

POSTGRADUATE MENTORING

Postgraduate Supervision

2019-2020 Postdoctoral advisor to Mr Konstantin Asteriadis, Ph.D. candidate at Karlsruhe Institute of Technology, Germany (supervisor: Prof. Kirill Melnikov).
Mr Asteriadis has successfully defended his doctorate and has accepted a postdoctoral position at Brookhaven National Laboratory, USA.

Teaching at International Schools for Postgraduates

August – September 2019 Discussion leader at CERN-Fermilab Hadron Collider Physics School
CERN, Geneva, Switzerland
I was the theorist in charge of a group of a dozen students, and met with them daily to guide them through various advanced research topics presented in lectures, which were beyond those encountered in standard graduate-level classes.

March 2018 Delivered lectures on “*Infrared subtraction in perturbative QCD*”
School and Workshop on pQCD@West Lake
Zhejiang University, Hangzhou, China

SCIENTIFIC ORGANIZATION AND SERVICE

2019 – present Convener, Offshell Subgroup of Higgs Working Group
The Higgs Working Group is the official CERN structure that fosters communication between international experts to guide theoretical and experimental studies of the Higgs boson.

2020 – present Organizer, Collider Physics Cross-Talk
CERN
Geneva, Switzerland

2019 – present Referee, Journal of High Energy Physics

2020 Convener, QCD/EW parallel session
QCD@LHC Workshop
Bologna, Italy

2018 Convener, top quark parallel session
Conference on Large Hadron Collider Physics (LHCP)
Bologna, Italy

2016 – 2018 Organizer, Particle Physics Colloquium
Karlsruhe Institute of Technology
Karlsruhe, Germany

2015 – 2016 Organizer, Theory Group Seminars
Fermilab
Batavia, Illinois, USA

PUBLIC OUTREACH

- 2019 Volunteer at CERN Open Day
CERN, Geneva, Switzerland
Participated in the “Ask a Theorist” Exposition, engaging with members of the general public and answering their questions about the Large Hadron Collider and particle physics.
- 2012 – 2015 Volunteer at “Saturday Physics” Lecture Series
Fermilab, Batavia, Illinois, USA
This program is aimed at high school students and held weekly lectures and tours of the laboratory facilities over several months.

RESEARCH ACTIVITIES

My field is theoretical high-energy particle physics, focusing on perturbative quantum chromodynamics (QCD) and collider physics. My research concentrates on *the development of methods for precision predictions* in perturbative QCD, and *the applications of these methods to phenomenology* at the Large Hadron Collider (LHC), with the goal of scrutinizing the Standard Model (SM) of particle physics. During my doctoral studies and my subsequent postdoctoral career, I have investigated the following broad topics:

1. *The structure of higher order calculations in QCD;*
2. *Precision phenomenology of the Standard Model;*
3. *Precision phenomenology as a gateway to New Physics.*

I elaborate on these topics below. The references given refer to the publication list in this document.

1. The structure of higher order corrections

The high precision program at the LHC depends crucially on the availability of reliable theoretical predictions. These entail sophisticated calculations in a complex collider environment, including expansions to (at least) next-to-next-to-leading order (NNLO) in perturbative quantum chromodynamics (QCD). These corrections are not only phenomenologically essential but are also interesting from a purely theoretical perspective, as they necessitate further explorations of the *structures underlying QCD*. Much of my recent work has focused on understanding these structures in the development of improved methods for computing higher order corrections.

Infrared singularities at next-to-next-to-leading order

There are two main obstacles in higher order QCD calculations: computing loop amplitudes, and treating infrared singularities. My most recent work has focused on the second of these. Although results obtained in perturbative QCD are not dependent on long-distance correlations, the quantum nature of QCD means that these effects arise at intermediate stages of the calculations as infrared singularities. These singularities have a convoluted structure, so treating them in a fully differential manner (i.e. without losing information on the final state particles) is a delicate theoretical problem. With my collaborators, I recently proposed a new method of addressing this issue, called the *nested soft-collinear subtraction (NSS) scheme* [8]. This framework fully exploits insight into the infrared structures of QCD by using the property of *color coherence*, allowing the separate treatment of soft and collinear singularities. This leads to a minimal method of iterative subtractions of singular limits. As a result of the theoretical clarity of the method, we were able to formulate it in a manner that is both *fully analytic* and *fully local* in radiative phase space [3, 5, 6]. A byproduct of this deeper understanding is the promise of improved numerical performance, which has been confirmed in proof-of-concept studies. I have already used the NSS scheme for several high-precision LHC studies (described below). The method has great potential for treating the infrared

singularities in more complicated LHC production processes, including those with final state jets, allowing NNLO-accurate predictions for these processes. This is one of the main goals of my future research plans. Additionally, tantalizing connections between fixed-order subtractions and *all-order formalisms* appear rather naturally in our framework, due to the nested nature which lies at its heart. This is intriguing from a theoretical standpoint, and further developing the NSS method and exploring these features is another key research objective of mine.

Mixed QCD-electroweak corrections

In addition to QCD corrections, processes at the LHC are also subject to electroweak (EW) corrections, which become important in the quest for high precision, especially as more highly energetic events are produced. These corrections have been studied extensively. However, the *mixed* impact of QCD and EW corrections is less well examined, even for the simplest processes, in part because of the difficulties in treating QCD and EW singularities which arise simultaneously in these calculations.

The insight gained from studying the singularity structures of multiple QCD emissions has allowed me to generalize the NSS framework to encompass QCD-EW singularities. Results for Z boson production were presented recently [4, P1]. The production of a W boson is complicated by photon radiation off the W boson, but this obstacle has been overcome and fully differential results for the mixed QCD-EW corrections to W boson production will be presented very soon. These studies pave the way to assess the impact of mixed QCD-EW corrections on the *ultra-high precision measurement of the mass of the W boson* at the LHC, as well as their effect on *BSM searches in high-mass dilepton signatures*.

Unitarity for one-loop amplitudes

My doctoral work focused on phenomenological investigations of diboson production, described in further detail below. These required the calculation of one-loop amplitudes with up to six external legs, which was at the cutting edge of loop technology at the time. I made use of modern *unitarity methods*, which were based on new understandings of scattering amplitudes and had just reached maturity, to perform these calculations. These methods relied heavily on the *color-ordering* of amplitudes, so I had to address several subtleties that arose in their application to a process with two colorless final states. Since then, I have used one-loop unitarity methods in many of the other phenomenological studies detailed below [11-14, 16].

2. Precision phenomenology of the Standard Model

High-precision comparisons between theoretical predictions and experimental data from the LHC are essential to uncover the properties of the Higgs boson, probe the mechanism of electroweak symmetry breaking (EWSB), and scrutinize the structure of the Standard Model. I have performed phenomenological studies for a wide range of LHC production processes, including studies of the Higgs boson, electroweak sector, and top quark. I describe these studies below.

Associated Higgs production and decay to bottom quarks

The production of *a Higgs boson in association with a weak gauge boson* is an important production mode, in particular because it allows the detection of the *Higgs decaying into a pair of bottom quarks* in boosted events. However, there are theoretical subtleties in the identification of final state bottom quarks. Indeed, naive flavor identification with the widely-used anti-kT jet algorithm is *infrared unsafe* at NNLO.

In order to investigate these issues, my collaborators and I studied Higgs production with a W boson followed by the Higgs decay to bottom quarks, using the NSS scheme described above to treat both the production and decay processes at NNLO. Our first study [7] considered massless bottom quarks, a commonly used approximation. We pointed out that this approximation is

theoretically incomplete, as it leads to non-trivial subleading-power logarithmic terms. Moreover, a non-standard jet algorithm must be used for infrared safe flavor identification, impeding a direct comparison with experimental data. For these reasons, we have recently extended our subtraction framework to handle *massive partons*, and performed the first NNLO study of this process in which the bottom quarks are consistently treated as massive [1]. This allows a more direct comparison between these predictions and LHC measurements. Contrary to what one might naively expect, our results show that the massless approximation is particularly inadequate at *high transverse momenta* – i.e. in the boosted regime that is relevant for studies of $H \rightarrow b\bar{b}$ decay – because of subtleties in the jet recombination procedure. This has stimulated discussion regarding the development of a better jet algorithm for flavor identification.

This work has also spurred my interest in the treatment of final state heavy flavors (i.e. bottom and charm quarks). One of my other research goals is to explore the inclusion of mass effects (e.g. using fragmentation functions), using *heavy flavor production in association with an electroweak gauge boson* as a testing ground. NNLO accuracy could provide important insight into these processes and complement other approaches, such as parton showers. Moreover, studies of $W+c$ production may provide further information on the strange quark content of the proton.

Offshell Higgs production

Most studies of the Higgs boson at the LHC focus on its onshell production. However, offshell Higgs production also provides vital insight into the nature of this particle: it can provide stringent constraints on the Higgs width, as well as probe the sensitivity of the Higgs couplings to high-energy BSM physics. Theoretical predictions of this process are complicated by interference effects with prompt diboson production and the need to compute massive loop amplitudes. For this reason, going beyond leading order is extremely challenging. While I was a research associate at Fermi National Accelerator Laboratory in the USA, my collaborators and I investigated the impact of *additional jet radiation* in offshell Higgs production on the determination of the Higgs width [15]. I built on this work during my time at the Karlsruhe Institute of Technology (KIT), and presented the first comprehensive study of *next-to-leading order* (NLO) effects on offshell Higgs production [11]. These results are routinely used by both the ATLAS and CMS collaborations in their offshell Higgs analyses.

Since the beginning of 2019, I have been serving as convener of the Offshell Subgroup of the LHC Higgs Working Group, the official CERN structure which fosters communication among international experts to guide theoretical and experimental studies of the Higgs boson.

Diboson production

The production of two weak gauge bosons is a key process at the LHC. It is an important background for Higgs boson and top quark studies, and is also interesting in its own right as a test of the gauge structure of the SM and in searches for BSM physics through modifications of the gauge couplings.

My doctoral work at the University of Oxford in the United Kingdom centered on the production of *same- and opposite-sign WW production in association with two jets*, to NLO accuracy [20, 22]. These processes are particularly interesting as backgrounds for Higgs production through weak boson fusion, and as such were included in the 2005 Les Houches Wishlist of processes whose NLO-accurate predictions would be important for the LHC program. These calculations were made possible by advances in unitarity methods for one-loop amplitudes, outlined above.

The last part of my doctoral research was on the *gluon-induced production of two W bosons and a jet* [18]. I continued my studies of loop-induced diboson production while working at Fermilab and KIT, presenting the NLO corrections to ZZ and WW production through gluon fusion [12, 13]. These results have been widely used by experimental collaborations, and were a precursor to the study of offshell Higgs production [11], described above.

I have also matched NLO calculations of several diboson production processes to *parton showers* using the POWHEG method, to allow for predictions of *experimentally realistic final states* with NLO accuracy. Most recently, my collaborators and I have matched the NLO calculation of *gluon-induced ZZ production* (mentioned above) with parton showers [9]. Work to extend this to include *offshell Higgs production* (also discussed above) is ongoing. During my doctoral studies, my collaborators and I matched the NLO predictions for *WW*, *WZ* and *ZZ* production with parton showers [19]. The resulting computer code is publicly available in the POWHEG-BOX program, and has been extensively used in experimental analyses. I also matched the production of *same-sign W bosons with two jets* (mentioned above) to parton showers [21]. This was the first four-particle production process whose NLO prediction was matched to parton showers, and the code is also publicly available in the POWHEG-BOX program.

Top physics

The top quark is the heaviest fundamental particle known, and is the only quark which decays prior to hadronization. As such, top quark studies provide an opportunity to study the interplay between perturbative and non-perturbative QCD. Moreover, the interactions between the top quark and the Higgs boson and electroweak sector provide an important window into EWSB. I have performed several studies of top quark production in association with a Z boson. Together with collaborators at Fermilab, I presented the first NLO predictions for *single top production in association with a Z boson* [17], and made the code publicly available as part of the MCFM program. Interestingly, despite being of relatively low multiplicity, this process is sensitive to almost all top operators in the effective field theory extension of the SM. As such, it can provide valuable insight into the top, Higgs, and electroweak sectors of the SM.

3. Precision phenomenology as a gateway to New Physics

The LHC has not seen unambiguous evidence for BSM physics to date, and searches for New Physics effects are increasingly focused on their manifestation as subtle modifications of SM signatures. Below, I describe my investigations of the indirect effect of BSM physics in the Higgs and top sectors.

Parity of the Higgs boson

Although initial measurements indicate that the Higgs is a scalar particle, the possibility that it is an *admixture* of scalar and pseudoscalar states has not been excluded. If this were to be discovered, it would imply CP violation in the Higgs sector. This would have wide-ranging implications for the SM, BSM physics, and the physics of the early universe. I recently investigated this possibility together with a postdoctoral researcher at KIT [2], studying several observables which are sensitive to the Higgs parity. We employed the NSS method discussed above to perform these studies at NNLO accuracy. This is particularly important because the structures of the Higgs scalar and pseudoscalar production amplitudes are *identical at leading order and NLO*, but *differ at NNLO*. This means that NNLO accuracy is required to study scalar-pseudoscalar admixture effects in Higgs production.

Interactions of the Higgs boson with third generation fermions

Together with a fellow theory postdoctoral researcher and two CMS experimentalists, I studied *anomalous Higgs couplings to third generation fermions*, including CP-violating interactions [10]. We considered a number of production and decay channels in which the Higgs couples to heavy fermions, and extended the so-called *matrix element method* to these processes. This gave us a powerful statistical tool to analyse the impact of new physics in these channels and to study the sensitivity of the LHC to such effects.

Interactions of the top quark with the electroweak sector

As mentioned above, the interactions between the top quark and the electroweak sector are important in understanding EWSB. While at Fermilab, I worked with a CERN Fellow to investigate the potential of the LHC and the mooted International Linear Collider to constrain the *top quark coupling to the Z boson*, including the *weak electric* and *magnetic dipole moments* of the top quark [14,16]. We showed that the reduced theory uncertainties accompanying NLO-accurate predictions could have a substantial impact on the determination of the top-Z coupling.

INVITED TALKS

Invited Talks at International Conferences and Workshops:

June 2019	<i>"Subtraction Methods at Next-to-next-leading order"</i> Recontres de Blois, Blois, France.
October 2018	<i>"Nested soft-collinear subtractions for NNLO color singlet production"</i> Workshop on "Amplitudes in the LHC Era", Florence, Italy.
August 2018	<i>"Nested soft-collinear subtractions"</i> Workshop on "High Time for Higher Orders", Mainz, Germany.
July 2018	<i>"Nested soft-collinear subtractions for color singlet production and decay"</i> Loopfest XVII, East Lansing, USA.
April 2018	<i>"Nested soft-collinear subtractions for NNLO calculations"</i> Workshop on "Subtracting Infrared Singularities Beyond NLO", Edinburgh, UK
September 2017	<i>"Nested soft-collinear subtractions for NNLO calculations"</i> Radcor 2017, St Gilgen, Austria
March 2017	<i>"NLO Corrections to VV production through gluon fusion"</i> Rencontres du Moriond, La Thuile, Italy.
January 2017	<i>"Offshell Higgs production and interference effects at NLO"</i> Zurich Phenomenology Workshop, Zurich, Switzerland.
September 2016	<i>"Offshell Higgs production and interference effects at NLO"</i> Rencontres du Vietnam, Qui Nhon, Vietnam.
August 2016	<i>"Higgs interference effects at NLO"</i> Higgs Hunting, Paris, France.
August 2016	<i>"NLO Corrections to VV production through gluon fusion"</i> Loopfest XIV, Buffalo, USA.
August 2016	<i>"Higgs off-shell effects at NLO"</i> International Conference on High Energy Physics, Chicago, USA.
October 2015	<i>"Constraints on top-Z couplings from current and future colliders"</i> Workshop on "QCD, EW and tools at 100 TeV", CERN, Geneva, Switzerland.
November 2014	<i>"Interference effects and the Higgs Width"</i> "BSM Higgs Workshop @ LPC", Fermilab, USA

July 2014	<i>"Constraining the top-Z coupling through $t\bar{t}Z$ production at the LHC"</i> . International Conference on High Energy Physics, Valencia, Spain.
June 2014	<i>"Constraining the top-Z coupling through $t\bar{t}b\bar{b}Z$ production at the LHC"</i> . Loopfest XIII, New York, USA.
May 2014	<i>"Constraining the top-Z coupling through $t\bar{t}b\bar{b}Z$ production at the LHC"</i> . Americas Workshop on Linear Colliders, Fermilab, USA.
August 2013	<i>"Calculating and modeling $W W jj$, $t\bar{t}b + j$ and $W + jets$"</i> . LPC Workshop on Gauge Boson Couplings, Fermilab, USA.
May 2013	<i>"Single top production in association with a Z boson"</i> . Loopfest XII, Tallahassee, USA.
July 2011	<i>"$W^+ W^- + dijet$ to next-to-leading order in QCD"</i> . European Physical Society conference on High Energy Physics, Grenoble, France.

Invited Seminars:

May 2019	<i>"Nested soft-collinear subtractions for infrared singularities at NNLO"</i> University of Vienna, Austria
July 2018	<i>"Associated WH production and $H \rightarrow b\bar{b}$ decay at NNLO QCD"</i> Michigan State University, USA
May 2018	<i>"Associated WH production and $H \rightarrow b\bar{b}$ decay at NNLO QCD"</i> University of Würzburg, Germany
September 2017	<i>"A Guided Tour through an NNLO Subtraction Scheme"</i> University of Zurich, Switzerland
June 2017	<i>"A Guided Tour through an NNLO Subtraction Scheme"</i> Humboldt University Berlin, Germany
April 2017	<i>"A Guided Tour through an NNLO Subtraction Scheme"</i> Max Planck Institute Munich, Germany
November 2016	<i>"Gluon-induced diboson production at the LHC"</i> Durham University, UK
December 2014	<i>"Off-shell Effects and the Higgs Width"</i> Argonne National Laboratory, USA
July 2014	<i>"Constraining the top-Z coupling through $t\bar{t}b\bar{b}+X$ production at the LHC"</i> ETH Zurich, Switzerland
February 2014	<i>"Constraining the top-Z coupling through $t\bar{t}Z$ production to NLO in QCD"</i> Johns Hopkins University, USA
May 2013	<i>"Higher order QCD effects in WW production with jets"</i> Florida State University, USA

March 2013 *“Higher order QCD effects in WW production with jets”*
Northwestern University, USA

January 2013 *“Higher order QCD effects in WW production with jets”*
Argonne National Laboratory, USA

Research Visits:

June 2019 Visiting scientist at workshop *“Physics at TeV Colliders”*
Les Houches, France

October 2018 Visiting scientist at workshop *“Amplitudes in the LHC Era”*
Galileo Galilei Institute for Theoretical Physics
Florence, Italy

August 2018 Visiting scientist at workshop *“High Time for Higher Orders: From Amplitudes to Phenomenology”*
Mainz Institute for Theoretical Physics (MITP)
Mainz, Germany

August 2017 Visiting scientist at workshop *“Automated, Resummed and Effective: Precision Computations for the LHC and Beyond ”*
Munich Institute for Astro- and Particle Physics (MIAPP)
Munich, Germany

June-July 2017 Visiting scientist at workshop *“LHC and the Standard Model: Physics and Tools”*
CERN
Geneva, Switzerland

June 2017 Visiting scientist at workshop *“Physics at TeV Colliders”*
Les Houches, France

August 2016 Visiting scientist at workshop *“Effective Field Theories as Discovery Tools”*
Mainz Institute for Theoretical Physics (MITP)
Mainz, Germany

LIST OF PUBLICATIONS

Peer-reviewed articles:

Please note that authors are listed alphabetically in theoretical particle physics publications. The presence of my doctoral supervisor (Prof. Giulia Zanderighi) is highlighted in boldface.

1. Arnd Behring, Wojciech Bizoń, Fabrizio Caola, Kirill Melnikov and Raoul Röntsch
Bottom quark mass effects in associated W H production with $H \rightarrow b\text{-}b\bar{b}$ decay through NNLO QCD
Phys. Rev. D**101**, 114012, 2020.

2. Matthieu Jaquier and Raoul Röntsch
Mixed scalar-pseudoscalar Higgs boson production through next-to-next-to-leading order at the LHC
JHEP **2006**:005, 2020.

3. Konstantin Asteriadis, Fabrizio Caola, Kirill Melnikov and [Raoul Röntsch](#)
Analytic results for deep-inelastic scattering at NNLO QCD with the nested soft-collinear subtraction scheme
Eur. Phys. J. C80, 8, 2020.
4. Maximilian Delto, Matthieu Jaquier, Kirill Melnikov and [Raoul Röntsch](#)
Mixed QCD x QED corrections to on-shell Z boson production at the LHC
JHEP 2001:043, 2020.
5. Fabrizio Caola, Kirill Melnikov and [Raoul Röntsch](#)
Analytic results for decays of color singlets to gg and qqbar final states at NNLO QCD with the nested soft-collinear subtraction scheme
Eur. Phys. J. C79, 1013, 2019.
6. Fabrizio Caola, Kirill Melnikov and [Raoul Röntsch](#)
Analytic results for color-singlet production at NNLO QCD with the nested soft-collinear subtraction scheme
Eur. Phys. J. C79, 386, 2019.
7. Fabrizio Caola, Gionata Luisoni, Kirill Melnikov and [Raoul Röntsch](#)
NNLO QCD corrections to associated WH production and $H \rightarrow b\text{-}b\text{bar}$ decay
Phys. Rev. D97, 074022, 2018.
8. Fabrizio Caola, Kirill Melnikov and [Raoul Röntsch](#)
Nested soft-collinear subtractions in NNLO QCD computations
Eur. Phys. J. C77, 2017.
9. Simone Alioli, Fabrizio Caola, Gionata Luisoni and [Raoul Röntsch](#)
ZZ production in gluon fusion at NLO matched to parton-shower
Phys. Rev. D95, 034042, 2017.
10. Andrei V. Gritsan, [Raoul Röntsch](#), Markus Schulze and Meng Xiao
Constraining anomalous Higgs boson couplings to the heavy flavor fermions using matrix element techniques
Phys. Rev. D94, 055023, 2016.
11. Fabrizio Caola, Matthew Dowling, Kirill Melnikov, [Raoul Röntsch](#) and Lorenzo Tancredi
QCD corrections to vector boson pair production in gluon fusion including interference effects with off-shell Higgs at the LHC
JHEP 1607:087, 2016.
12. Fabrizio Caola, Kirill Melnikov, [Raoul Röntsch](#) and Lorenzo Tancredi
QCD corrections to $W+W^-$ production through gluon fusion
Phys. Lett. B752, 275, 2016.
13. Fabrizio Caola, Kirill Melnikov, [Raoul Röntsch](#) and Lorenzo Tancredi,
QCD corrections to ZZ production in gluon fusion at the LHC
Phys. Rev. D92, 092028, 2015.
14. [Raoul Röntsch](#) and Markus Schulze
Probing top-Z dipole moments at the LHC and ILC.
JHEP 1508:044, 2015
15. John M. Campbell, R. Keith Ellis, Elisabetta Furlan and [Raoul Röntsch](#)
Interference effects for Higgs-mediated Z-pair plus jet production
Phys. Rev. D90, 093008, 2014.

16. [Raoul Röntsch](#) and Markus Schulze
Constraining coupling of the top quarks to the Z boson in $t\bar{t}b+Z$ production at the LHC
JHEP 1407:091, 2014.
17. John Campbell, R. Keith Ellis and [Raoul Röntsch](#)
Single top production in association with a Z boson at the LHC
Phys. Rev. D87, 114006, 2013.
18. Tom Melia, Kirill Melnikov, [Raoul Röntsch](#), Markus Schulze and **Giulia Zanderighi**
Gluon fusion contribution to $W+W-$ + jet production
JHEP 1208:115, 2012.
19. Tom Melia, Paolo Nason, [Raoul Röntsch](#) and **Giulia Zanderighi**
 $W+W-$, WZ and ZZ production in the POWHEG BOX
JHEP 1111:078, 2011.
20. Tom Melia, Kirill Melnikov, [Raoul Röntsch](#) and **Giulia Zanderighi**
NLO QCD corrections for $W+W-$ pair production in association with two jets at hadron colliders
Phys. Rev. D83, 114043, 2011.
21. Tom Melia, Paolo Nason, [Raoul Röntsch](#) and **Giulia Zanderighi**
 $W+W+$ plus dijet production in the POWHEG-BOX
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22. Tom Melia, Kirill Melnikov, [Raoul Röntsch](#) and **Giulia Zanderighi**
Next-to-leading order QCD predictions for $W+W+$ jj production at the LHC
JHEP 1012:053, 2010.
23. C.A. Dominguez, N.F. Nasrallah, [R. Röntsch](#) and K. Schilcher
Up and down quark masses from Finite Energy QCD sum rules to five loops
Phys. Rev. D79, 014009, 2009.
24. C.A. Dominguez, N.F. Nasrallah, [R. Röntsch](#) and K. Schilcher
Strange quark mass from finite energy QCD sum rules to five loops
JHEP 0805:020, 2008.
25. C.A. Dominguez and [R. Röntsch](#)
Electromagnetic form-factors of the $\Delta(1232)$ in dual-large $N(c)$ QCD,
JHEP 0710:082, 2007.

Articles pending review:

[P1]. Federico Buccioni, Fabrizio Caola, Maximilian Delto, Matthieu Jaquier, Kirill Melnikov and [Raoul Röntsch](#)
Mixed QCD-electroweak corrections to on-shell Z production at the LHC
arXiv:hep-ph/2005.10221 [submitted to Phys. Lett. B.]

Conference proceedings:

My conference proceedings (not refereed) can be found below. Please note that in theoretical particle physics, proceedings are not required for every conference.

1. [Raoul Röntsch](#)
Nested soft-collinear subtractions for NNLO calculations
PoS RADCOR2017, 2018.

2. R. Röntsch, F. Caola, M. Dowling, K. Melnikov, L. Tancredi
Higgs off-shell effects at NLO,
PoS ICHEP2016, 2016.
3. Raoul Röntsch, Markus Schulze
Constraining the top-Z coupling through $t\bar{t}Z$ production at the LHC
Nucl. Part. Phys. Proc. 273-275, 2016.
4. Raoul Röntsch
 $W^+ W^- + \text{dijet}$ to next-to-leading order in QCD,
PoS EPS-HEP2011, 2011.
5. C.A. Dominguez, N.F. Nasrallah, R. Röntsch and K. Schilcher
Light quark masses from QCD sum rules with minimal hadronic bias
Nucl. Phys. Proc. Suppl. 186, 2009.

Contributions:

The particle physics community undertakes various studies to review the current state of the field and outline future directions of research; I have contributed to the following such studies:

1. S. Amoroso *et al.*
Les Houches 2019: Physics at TeV Colliders: Standard Model Working Group Report
2. M. Cepeda *et al.*
Higgs Physics at the HL-LHC and HE-LHC
3. J. R. Andersen *et al.*
Les Houches 2017: Physics at TeV Colliders Standard Model Working Group Report
4. LHC Higgs Cross Section Working Group (D. de Florian *et al.*)
Handbook of LHC Higgs Cross Sections: 4. Deciphering the Nature of the Higgs Sector

Data

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