# Curriculum vitae

## Tord Riemann

November 2015

I was born in 1951 in Berlin-Prenzlauer Berg (East Berlin) and visited the Heinrich-Hertz Gymnasium [then: erweiterte Oberschule] in Berlin. I completed the Abitur in 1970 with final mark "very good". The Heinrich-Hertz Gymnasium was one of the very few schools in East Germany with extended mathematical education and with a pre-selection of pupils by examination. 1951-1970
Some private information may be found at the webpage http://hugo-riemann.de.

I studied physics at Humboldt University in Berlin from 1972 to 1977. The diploma and Ph.D research was conducted under guidance of Professor F. Kaschluhn, head of the Department of Theoretical Physics at Humboldt University, and Dr. Hans Kaiser, staff in the Theory Group of the Institute for High Energy Physics (IfH) of the Academy of Sciences of GDR in Zeuthen (since 1992: DESY, Zeuthen campus). My research in this period was devoted to studies of the lattice approach to quantum field theory using expansions in the kinetic term of the Lagrangian. Nowadays this is essentially lattice gauge theory. In the diploma thesis I developed a graph scheme for the expansion of the four-point function of scalar fields, and in the Ph.D project I formulated the lattice approach for fermion fields. For QCD, this is now the Wilson approach. I found out that the language should be discretized functional integrals in Grassmannian variables and developed some graphical scheme for the kinetic expansions. I derived a heuristic derivation of a discretized Grassman functional integral as solution to the equation of the anti-commuting harmonic oscillator. Following articles by Tobocman and Candlin. Occasionally, I met Candlin many years later at a conference and he was truly astonished that anybody profited from his paper. But the study did not find the way into my thesis, because the advisor did not like it. Frankly speaking, I did not get anything else which I would find interesting by today. In parallel to our research, Lattice QCD was formulated by K. Wilson and was rapidly developing. 1972-1977

After the Ph.D thesis defence in June 1977 at Humboldt University I got a non-permanent research position in the Theory Group of IfH in Zeuthen. I became permanent in 1983. 1977

Because we were completely isolated from the rest of the world, I decided to change my research subject radically. My obligation was to cooperate to some extent with experimentalists in Zeuthen, and so I followed the invitation by Max Klein to work on weak interactions in the newly established gauge theories of weak interactions, notably the Glashow-Weinberg-Salam theory. He was member of the BCDMS collaboration at CERN. The experiment was studying muon-nucleon interactions at high energies with a potential to observe electro-weak interference effects. I author several phenomenological papers on this subject, as well as few papers on phenomenology of neutrino physics.

1980,2000

Around 1980, I formulated an on-shell renormalization of the (by now: standard) electroweak model, together with Gottfried Mann, now staff at Astrophysical Institute Potsdam (AIP). We applied the formalism to the study of fermion number violating decays of the $Z$ boson and obtained the first predictions for that kind of processes. The rates in the Standard Model are by far too small to be observed. Later, around the year 2000, together with Jose Illana I came back to the subject in connection with physics studies for the TESLA/ILC projects, and assuming the existence of heavy neutrinos such reactions might be observable. Illana later studied supersymmetric phenomena which are also promising. In 1986, together with Akhundov and Bardin, we studied the $Z$ boson 1986
life time in the Standard Model. For the first time (in parallel to Beenakker/Hollik and to Jegerlehner), we calculated the influence of a heavy top mass on the $b$-quark final state, due to vertex corrections. The formulae are related to those for the flavour violating effects mentioned, so that this Standard Model study profited from the earlier project.

1983-1987

In September 1983, I changed for four years (until August 1987) to the Laboratory for Theoretical Physics (LTPh) of the Joint Institute for Nuclear Research (JINR) at Dubna, Russia (then: Soviet Union). I started to work with D. Bardin and further collaborators on phenomenological effects at high energy accelerators in the electroweak Standard Model. Because at that time the Zeuthen experimentalists joined the L3 collaboration of Sam Ting, and the JINR experimentalists joined Delphi, we decided to study $e^+e^-$ annihilation at LEP energies. The traditional field of research of the Dubna group of Bardin was, among others, one-loop corrections to lepton-nucleon scattering, and there initially the pure QED corrections. The latter effects are large, and the Dubna group became leading worldwide in complete, precise predictions of higher-order corrections with numerous applications in various experiments. Until today.

The specifics of $e^+e^-$ annihilation is in its Minkowskian kinematics, while $lN$ scattering is basically Euklidean. In technical terms, the difference is substantial because the Feynman diagrams for $e^+e^-$ annihilation are complex quantities, and not real ones as in deep inelastic scattering. Further, the energy at LEP is chosen such that one is on top of the $Z$ boson resonance, and fixed order perturbation theory fails due to the divergence of the "naive" $Z$ boson propagator. One has to derive a consistent on-shell renormalization with a Breit-Wigner $Z$ propagator. Further, due to the mixing of $Z$ boson and photon, this has to be formulated in matrix form.

Beginning in September 1983, I took responsibility for these conceptional questions and we solved all of them, but we were faced with the fact that there existed already few complete calculations of the electroweak corrections at the $Z$ resonance. So the question arose, what to contribute to the field? We decided to try to get something original in performing analytical calculations of the QED corrections at LEP, thus embedding the weak effects. It took us several years of dedicated work (1983-1987/88, a group around

Bardin/Fedorenko/Riemann) with huge SCHOONSCHIP programs and huge tables of complicated bremsstrahlung integrals to get this work to some results. A publication in a journal failed, unfortunately, because the referee claimed that the work is not close enough to experimental set-ups. He did not recognise the extreme elegance of few-lines formulae for complete integrations in presence of a resonance.

We went on with refining the approach, and were able, in a relatively short term, to 1988-1991
present analytical results for QED bremsstrahlung predictions with several cuts. This was around 1989/91. Due to the need of exponentiation of soft photon effects, we had to change from an analytical approach to a semi-analytical one, but the enormous speed of our packages was not too much damaged by that. The essential technical point here was our decision to expand the module squared $Z$-boson propagator under the phase space integrals into the difference of two inverse linear complex functions. This enabled us to apply the theory of complex functions for the integrations, which I worked out in all the details. Without that we would not have been able to do the analytical integrations, and in fact our formulae remained unique until today. Another important technical trick for the integrations uses the feature of the quantum field theoretical $Z$-width function to be (around the $Z$ boson peak) just proportional to the integration variable $s'$. This allows to apply the so-called $Z$-parameter transformation, and then to integrate analytically. I worked this out in 1987, and as a result one may use ZFITTER both for constant or $s$-dependent width functions without crucial changes. Later we at Dubna learned that the underlying theoretical feature is the change between an on-mass and a complex pole mass definition of the $Z$ boson. At CERN, this was discussed at the LEP workshops, but we did not participate. It was our observation, that the difference is of great numerical importance.

These QED formulae, used as flux functions for the integrals over weak effective Born cross sections in the Standard Model, are the kernel of the ZFITTER project until today. Besides the weak loops. I come back to this project later again.

In parallel to the QED developments, we explored our library of weak Standard Model 1986
corrections for few phenomenological studies. In Physics Letters B, we put forward in 1986 the first plot confronting $Z$ mass and effective weak mixing angle in dependence on the top quark and the Higgs boson mass, thus seeking predictions for $m_{top}$ and $M_{Higgs}$ from LEP precision measurements. This was basically due to the by now famous function $\Delta r$, relating $M_W, G_{Fermi}, \alpha_{QED}$ as a function of the masses of the theory. Further, also in 1986 in two articles in Nuclear Physics B we derived the $Z$-boson and the $W$-boson widths and the predictions mentioned before.

In parallel to the $e^+e^-$-project, we started (with Fedorenko and P. Christova and oth- 1987
ers) a project on the study of electroweak corrections for the HERA $ep$-scattering project at DESY, Hamburg, where the Zeuthen experimentalists participated in the H1 experiment. The exploratory phase was in the years 1987/1991. The results were distributed as the DISEP package, which is now part of the HECTOR package. We could essentially contribute to the consolidation of the electroweak loop corrections for HERA, with a special emphasis on the pure QED corrections. These we treated, as was done for LEP, in a strict analytical approach. This was completely complementary to the usual Monte-Carlo predictions. Our approach was further distinguished by two technicalities: One concerns bremsstrahlung. In $ep$ scattering this is essentially a purely real-valued problem. In order to be able to perform the analytical integrations a la ZFITTER, I prosed also here to invent

an artificial $Z$ width in the $Z$ propagators, thus allowing for partial fraction decomposition of the pure $Z$ squared contributions, and in turn to apply techniques of complex functions with cuts and all that. The corrections depended in intermediate steps on inverse powers of $\Gamma_Z$, but the final expressions were again extremely compact and free of any artificial width function at all; as it has to be. The other feature concerns the weak part of the formulae. We were able to formulate the weak corrections in terms of four weak gauge-invariant form factors, depending on the kinematical variables $s$ and $t$. Including e.g. also the $WW$ and $ZZ$ box diagrams. People call this sometimes the ZFITTER approach, but in fact we invented this for $ep$ physics, because here the box diagrams play a bigger role than at the $Z$ resonance. The HECTOR package was heavily used at HERA, and it is in use until now. 2002

I came back to this project in 2002, when we were contacted by the Krakow group (S. Jadach et al.) with a quest for weak loop corrections to $\bar{\nu}\nu\gamma$ production at LEP, to be inserted into their QED Monte Carlo program. This is a delicate task due to gauge invariance problems related to the charged current $W$-boson exchange in the $t$-channel contribution. In our electroweak $CC$-studies for HERA, we had developed a consistent treatment of this, and I transferred the approach to the LEP case. The program was successfully established and published, and also applied by experimentalists. 1987

Our group in Dubna was quite isolated. We had contact to colleagues from other countries basically at JINR, Dubna, because we could not travel, as one can do nowadays. I got an invitation to participate in the HERA workshop at Hamburg in 1987. We had prepared, for the workshop proceedings, a study describing our work. It was printed as a JINR preprint, but never got published elsewhere. Shortly before the HERA workshop was a meeting of the East German scientists at Dubna with participation of the East German ambassador Gerd König in the Soviet Union. Here a colleague of mine and me welcomed Gorbachow's perestroika in a way that lead to the decision to fire us and send us home to East Germany. We were able to prevent this, but the travel to the Hamburg HERA workshop was cancelled, we did not present our results there and thus did not contribute to the proceedings.

In 1987 I returned back to East Germany.

I was forbidden to travel from Summer 1987 until the begin of 1989, including even the former socialist countries. For this reason I could not follow e.g. the invitation by Marek Zralek from Katowice University to visit the XI$^{th}$ "Matter to the Deepest" conference in September 1987 in Szczyrk.

I had the first personal contact in Germany to colleagues working on LEP and HERA physics at the Ringberg workshop, organised by Hans Kühn at MPI Munich in 1989, and shortly later I could visit CERN for 4 weeks. 1989

Since 1989, I became better and better integrated in the international community of particle physicists. I am thankful that this happened to me, although it was at the age of 38, and this is quite late in terms of a scientific carrier. In East Germany, I could not expect that much happened in terms of a formal carrier. I did not write a habilitation thesis, and I was of course not asked to teach at a university.

From 1987 to 1989 I was working, at distance to JINR/Dubna, were I also was forbidden to stay, on refinements and applications of the ZFITTER and the HECTOR projects. An important observation in 1988 was on the numerical relevance of the difference between an $s$-dependent $Z$ width function and a constant $Z$ width, expressed by a simple analytical expression amounting to about $-34$ MeV. Berends/Hollik et al. observed the same at the same time, but purely numerically. For the ZFITTER project the analytical formula was absolutely crucial because this allowed to retain the complete Fortran package unchanged in both approaches, without changing more than two or three lines. Later we understood that the constant width approach corresponds to the location of the $Z$ pole in the complex energy plane and should be preferred. Electroweak two-loop renormalizations use the notation, and collegues working in mathematical physics also got interested later (Arno Bohm et al.).

1989

In 1989 I visited L3 at CERN, following an invitation by Samuel Ting, and we started a fruitful collaboration for the application of our ZFITTER project at LEP. As well as Bardin et al. did in Delphi.

We considered our project as a purely theoretical one, and so also the other LEP collaborations and anybody else had access to our software. It was, in modern language, an open-source project. We supported practically anybody who was interested in that, and we do so until today. In fact there are numerous applications. The most important ones are by the Lep collaborations and by the LEPEWWG. The so-called “blue-band plot” of the LEPEWWG was made with ZFITTER. It predicted the mass of the Higgs boson prior to its discovery. The plot is quoted in the long-version of the official reasoning for awarding the Nobel prize in physics in 2013 to François Englert and Peter Higgs.

In 1989 LEP operation started, and the first analyses used ZFITTER, which was run under another name and was basically yet unpublished and rapidly developing yet. But only for the correction of data, and not for prestigious electroweak fits to data. This changed smoothly when better data were taken, and when people started to trust our software. The publications on ZFITTER with many detailed information on its contents and use played a role. We published about 350 pages of descriptions of the package, not to mention the purely theoretical articles on the underlying theory. See the ZFITTER webpages `http://zfitter.education` and `http://sanc.jinr.ru/users/zfitter`.

1995

After about 1995 the scientific activities around ZFITTER changed from our own theoretical work to the integration of higher-loop corrections from other groups into ZFITTER; a task which was mainly done by Bardin, with the aid of others like me in the careful checking, documentation, user support and all that stuff. All this became a bit less interesting
to us, and in fact in 2005 Bardin decided to give up the ZFITTER support completely. This 2005
was a critical situation, and I took over the responsibility as a spokesperson since then. Let me only mention that ZFITTER version 6.42 was used by everybody, notably the LEP collaborations and the LEPEWWG, for the prestigeous final LEP physics analyses – but this ZFITTER version was unpublished until Summer of 2005. As mentioned, e.g. the famous “blue-band plot” with the prediction of the Higgs boson mass from electroweak measurements relies to a large extent on ZFITTER, because the other two competing projects (G. Passarino’s (et al.) TOPAZ0 and W. Hollik’s (et al.) BHM code) got to be outdated by that time. In 2005, I created the so-called ZFITTER support group, mainly for publication and support of ZFITTER v.6.42. The latest released version is 6.43. The ZFITTER support group was dissolved in March 2011 due to the Gfitter incident.

In these years I worked, besides many activities related to ZFITTER and HERA, on several projects related to LEP2. Let me mention 4-fermion production and Z’ physics.
We cooperated in this period also with Karol Kolodziej from Katowice University, with 2003-2005

contributions to his Monte Carlo project for top-pair production in $e^+e^-$ annihilation.

East Germany broke down in November 1989, shortly after the begin of LEP operation
in August 1989. The situation of my institute, as a part of the questioned Academy of 1989
Sciences, was completely unclear, and it was not excluded that it might get closed in the course of demolition of the East German academy of sciences. Finally it was DESY, notably supported by V. Soergel, P. Soeding, H. Fritzsch and other colleagues, which was
ready to integrate our institute at a smaller scale. 1992-
In December 1991 the Institute for High Energy Physics was dissolved. It was newly 2011
founded in January 1992 as part of DESY. I got a working contract in the Theory Group and was since then several times spokesperson of the group:
9/1993-8/1995, 4/2004-4/2008, 08/2009-07/2011.
We had the tradition to circulate the duty in the permanent staff.

1991/92

From September 1991 to August 1992 I worked for one year as research associate in the Theory Divison at CERN. Besides ZFITTER related topics, I worked out the so-called S-matrix approach to the $Z$ resonance. The idea is to confront a scattering amplitude in form of a Laurent expansion with a single simple pole (relying on mass and width of the $Z$ boson) directly to the experimental data. Also for the description of asymmetries. This approach is as model-independent as possible, but in order to achieve the necessary numerical accuracy one has to develop a sophisticated environment with various QED corrections. Finally I decided to create an interface to ZFITTER, which was realized together with S. Kirsch and M. Grünewald - SMATASY/ZFITTER. The corresponding fits were performed by L3 and the LEPEWWG, later also by other collaborations, and now there is new interest by the Fcc-ee project aiming at the production of about $10^{12}$ $Z$ bosons.

Since the nineteen nineties I took active part in several workshops on physics at LEP2 and the linear collider project.

1993-
Further, I was over decades, until 2011, node coordinator of subsequent research 2010
networks finanzed by the European Union:
1993-09 - 1996-06 Node coordinator of EUNEPHESMA, ”Phenomenology of the Standard Model and alternatives for present and future high energy colliders”, HCM project, framework 3C
8/2000-7/2004 Node coordinator of TMR Network (RTN) of the European Commission: ”Particle Physics Phenomenology at High Energy Colliders”
12/2006-11/2010 Node coordinator, member of steering committee, and network task coordinator for ”Tools” of TMR Network (RTN) of the European Commission: ”HEPTOOLS - Tools and Precision Calculations for Physics Discoveries at Colliders”

2003-
From 2003 to 2014 I was a Project Leader in Sonderforschungsbereich/Transregio 2014
(SFB/TRR 9) of Deutsche Forschungsgemeinschaft (DFG), project B1: ”Precision calculations of massive particle production processes”. The final report, authored together with Janusz Gluza from Katowice, gives a rather comprehensive overview on the activities related to the project.

since
I founded together with Johannes Blümlein in 1990 the bi-annual conference series 1990
”Loops and Legs in Quantum Field Theory“, which is by now the most important meeting devoted to radiative corrections in QFT.

since
2006

Since 2006, I am also Co-Chair or member of the local committee of the tri-annual workshop ”CALC - Calculations for Modern and Future Colliders”, JINR, Dubna, Russia.

since 2005

In 2005 I founded the bi-annual DESY School ”Computer Algebra and Particle Physics”, together with Sven Moch. It is the most advanced school on computer algebra for particle theorists.

Since decades I am in the advisory boards of several conference series: ”Radcor - Radiative corrections and applications of Quantum Field Theory to Phenomenology“ and ”ACAT - Advanced Computing and Analysis Techniques in physics research“ and ”Matter to the deepest“.

During the SFB/TR 9 activities a fruitful long-term collaboration with Janusz Gluza from Katowice University was started, for many years, also together with Jochem Fleischer from Bielefeld University (JF deceased in April 2013). We studied various topics in the calculation of complicated Feynman integrals and their application to advanced predictions of collider physics predictions.

2004-2008

Together with Michal Czakon, now professor at Aachen University, me and Janusz Gluza tried to calculate the master integrals for two-loop Bhabha scattering. Truly difficult are the double box diagrams. We were encouraged by the successful treatment of double boxes for jet production, but it came out that Bhabha scattering is much more involved, and the problem is unsolved until today. We learned a lot and got a variety of results nevertheless. Let me mention the complete set of planar double boxes as a small mass expansion. A new physical result was the two-loop contribution of virtual heavy fermions or hadrons to Bhabha scattering, which is needed to match the accuracy at meson factories (together with Gluza/Actis and also Czakon).

2006

We also studied, with Jochem Fleischer, the general $d$-dimensional one-loop box (and simpler integrals) in terms of generalized hypergeometric functions and of generalized harmonic polylogarithms. Different techniques were applied, notably systems of differential equations and Mellin-Barnes presentations for multi-loop integrals. In the course of this activity, we developed a Mathematica package for the automatized representation of Feynman integrals in terms of Mellin-Barnes integrals, AMBRE, which may be used in conjunction with Czakon's package MB for the calculation of such kind of integrals. I will come back to this point.

since 2006

In parallel, with Gluza and Fleischer (and others) we started a project for the calculation of NNLO corrections to collider physics at meson factories and at highest energies. We concentrated on the one-loop 5-point functions, which are usually numerically small and were neglected in earlier approaches. One of the main outcomes of this activity is the derivation and programming of tensor Feynman integrals in Mathematica and C++ or Fortran. This includes explicit formulae for 5- to 7-point functions with appropriate tensor rank. We use Davydychev's tensor reduction and Tarasov's recurrence relations in a rigid way, as it was not done before. The problem of numerical instabilities due to inverse vanishing Gram determinants, arising in the course of dimensional recurrences, can be treated in several ways. One chosen by us is the expression of 4-point functions by infinite series of 3-point functions, accompanied by subsequent Pade approximants. This procedure is automatized (programming by V. Yundin) and extremely stable and efficient. Another one is now under investigation with Johannes Blümlein et al. It is the representation of tensor integrals in $D = 4 - 2\epsilon$ dimensions by scalar one-loop 2- to 4-point functions in $D = 4 + n - 2\epsilon, n \geq 0$ dimensions, due to Davydychev. Their direct analytical evaluation in terms of hypergeometric functions, $F_1$-functions and the Saran $F_S$-function with subsequent expansion in $\epsilon$ is possible, and first results are promising. An alternative to tensor reduction is the formulation of perturbative solutions in terms of contracted Feynman integrals. For this, one has to perform certain finite sums over Cayley determinants. Me and Jochem Fleischer et al. have performed this programme, but a numerical programming for applications is waiting for completion.

since 2006

As was mentioned, studying the Bhabha two-loop box diagram problem (with M. Czakon) we collected some technical expertise in the calculation of multi-loop Feynman integrals by Mellin-Barnes integrals. We developed the Mathematica package AMBRE for this task, which prepares Feynman integrals for the treatment with Czakon's Mathematica package MB. The latter performes automated continuations of integration paths in the $n$-dimensional complex space with subsequent $\epsilon$-expansion. The resulting finite MB-integrals have to be calculated, numerically or analytically. We have a variety of applications of AMBRE by users, from collider cross-section calculations to lattice QCD (with contributions by us, under investigation) and string theoretical studies. The evaluations were for quite some time a true bottleneck of the approach. The reason is two-fold. One is the rising number of dimensions to be integrated over, with complexity of the integral in topology or number of parameters. The other one is the complex singularity structure when Minkowskian kinematics applies. It took us a while to push the approach in this respect to a new quality of usability (under development, with Gluza and my Ph.D. students I. Dubovyk and J. Usovitsch). The clever use of Cheng-Wu variables diminishes in many cases the number of dimensions to be integrated over, which is essential for calculating non-planar diagrams. This is an upgrade of AMBRE (software author: I. Dubovyk) and presently in preparation for publication. A clever change of the integration paths leads to the isolation of poles, allowing to separate the contribution of their residues, diminishing the absolute value of the high-dimensional rest integral. This has been automatized and is in effect the representation of MB-integrals by a series of lower-dimensional ones plus a rest. The corresponding Mathematica package MBnumerics (software authors J. Usovitsch and I. Dubovyk) further evaluates output from the MB package mentioned and replaces the MBnum subpackage of MB. A first version is presently in preparation for publication. With Michal Ochman I finished the development of a Mathematica package for transforming Melin-Barnes representations of feynman integrals into multiple sums. Once summation techniques will be available for classes of functions appearing here, this is a prospective analytical approach. I am in contact with the Linz group working on such kind of summations.

The new software is developed as support of our project on calculation of large amounts of two-loop vertex integrals with several scales as they appear typically in NNLO electroweak calculations. The MB-approach can, after the improvements described, compete in Minkowskian numerics with the sector decomposition approach. Certain problems are difficult in the latter, notably the class of so-called one-shell diagrams where a direct use of numerical public sector decomposition packages may fail completely. The project is not yet finished, but a first publication has been submitted. Finally, we aim at a (semi-)automated numerical calculation of two-loop vertices of the Standard Model. This will be important to have for the needed two-loop calculations for $e^+e^-$-collider projects.

These days I am profiting crucially from the close working relations with the Silesian University at Katowice, mainly with Professor Janusz Gluza. Since many years we cooperate in concrete projects and have common advice of Ph.D. students. Let me mention K. Kajda, V. Yundin, I. Dubovyk, J. Usovitsch. All of them financed by external ressources.

2001,2014

Above I described in some detail the ZFITTER project. The project comprises an FTE (full time equvalent of research) of about 2.2 million Euros. ZFITTER is until today the relevant software for studying the $Z$ boson resonance in the standard model of elementary particle physics. And for fitting studies relying on the precision $Z$ data; I mentioned the prediction of $t$-quark mass and Higgs boson mass prior to their discoveries. Nowadays, also Drell-Yan processes at Fermilab and at CERN's LHC may be described aided by ZFITTER. And the meson factory experiment Belle II plans to use ZFITTER for the experimental analysis of about $10^9$ $\mu^+\mu^-$-events, allowing the determination of the $\rho$ parameter with unprecedented precision. Without knowledge of the predicted electroweak value, an interpretation of the 'rest' in terms of New Physics will be impossible. The ZFITTER team was awarded the "First Prize of the Joint Institute for Nuclear Research, Dubna" on January 19, 2001 by the Scientific Council of the JINR Dubna for the project "Theoretical support of experiments at the Z resonance on precision tests of the standard model (Project ZFITTER)". The review of the ZFITTER project by A. Akhundov, A. Arbuzov, S. Riemann, T. Riemann in the JINR publication series Etschaya (Springer Verlag) was awarded the first prize for a theoretical article in 2014.

since 2011

In 2011, we ZFITTER authors detected (with confirmation by an independent software expertise in Germany in 2014) crucial improper use of the ZFITTER v.6.42 package by the Gfitter collaboration (J. Haller, A. Hoecker, M. Goebel et al., spokesperson K. Moenig) in their Gfitter/gsm package and in a variety of publications relying on it. The case is not solved. In the course of events it became evident that certain traditional rules of Good Scientific Practice in international academic basic research atre being questioned. By collegues working in the ATLAS collaboration at the LHC of CERN, but also by scientific leaders, some of them non-physicists, involved in the subsequent investigations. So I decided to organize a round table discussion at the international particle physics software conference ACAT in Beijing, China in 2013. Around 100 collegues participated and spelled out remarkably homogenous opinions. So, me and the two chairs of the conference (Federico Carminati from CERN and Denis Perret-Gallix from France) decided to publish a summary report of the main thesis of the discussion. Already before I gave conference talks on the subject. I consider this activity as crucial and plan to continue it in the future. If not the experienced researchers set and defend the standards of research, nobody will do this. Let me only remark that basic academic research lives from the equilibrium of competition and cooperation. Academic carriers - at all levels, including Nobel Prizes - depend on the fair attribution of advances to their individual authors. So, attributions are substancial and scientific misconduct has to be prevented and, if it happens, to be sanctioned. The minimal sanction is to make scientific misconduct public and to arrange for the necessary retractions. The special point in the conflict around the Gfitter incident here is that many persons do not consider software like ZFITTER as a result of research which deserves the same status of originality like new data, analytical formulas, texts, or figures. Further, it became evident that the interests of socially weaker groups of researchers are less respected than those of scientists working at big centers, in big experiments, or in rich countries.

since 2009

I mentioned several times the long-term collaboration with J. Gluza from Katowice University. From this activity, we derived a long-term project related to the PHOKHARA

Monte Carlo generator of Henryk Czyż. This is the world-leading software for QED corrections to a variety of exclusive production processes at meson factories. What was lacking in PHOKHARA, due to the complexity and expected smallness, were the NNLO corrections from loop corrections to real photon emission, arising from 5-point functions. We studied this for muon pair production, and with PHOKHARA it was demonstrated that the effect is really small, although in distributions not as tiny as was proposed. There is a competing project on these 5-point contributions, and it came out in the comparisons that our approach is very stable, fast and flexible (with J. Gluza, V. Yundin et al.). Here, we plan to add further processes. In principle, the theoretical problems are solved. From LHC applications one might think that the theoretical issues are solved completely. But the cross sections at meson factories have their own specifics which makes their correct numerical description demanding.

**Teaching and education** since 2006

All over the years I gave occasional seminars and lectures. Since 2006 I hold regular lecture courses at Potsdam University and at Dresden University, on renormalization and phenomenology of the Standard Model and on collider physics. I was thesis advisor of 2 diploma theses (both finished) and 7 PhD projects (5 finished).

Ph.D Students:

J. Usovitsch, at Humboldt-Universität zu Berlin, starting November 2014. Co-supervisor: Prof. P. Uwer

I. Dubovyk, at Universität Hamburg, starting October 2014. Supervisor at UHH: Prof. S. Moch

Dr. V. Yundin, Ph.D. Thesis (Humboldt-Universität zu Berlin 2012): ”Massive loop corrections for collider physics”. Co-supervisor: Prof. J. Plefka

Dr. A. Lorca, Ph.D. Thesis (Universität Bielefeld 2005): ” Calculation and automation of one-loop corrections to 2-to-2 fermion processes”. Co-supervisor: Prof. J. Fleischer

Dr. M. Jack, Ph.D. Thesis (Humboldt-Universität zu Berlin 2000): ”Semi-analytical calculation of QED radiative corrections to $e^+e^-\bar{f}f$ with special emphasis on kinematical cuts to the final state”. Co-supervisor: Prof. M. Müller-Preussker

Dr. J. Biebel, Ph.D. Thesis (Humboldt-Universität zu Berlin 2001): ”Predictions for the search for anomalous couplings of gauge bosons and leptons in $e^+e^-$ scattering”. Co-supervisor: Prof. D.Lüst

Dr. D. Lehner, Ph.D. Thesis(Humboldt-Universität zu Berlin 1995) ” Initial state radiative corrections to Z0 pair production in $e^+e^-$ annihilation: The Semianalytical approach”. Co-supervisor: Prof. M. Müller-Preussker Diploma Students:

F. Haas, Diploma thesis (Universität Potsdam 2008): ”Application of Mellin-Barnes representations to the evaluation of radiative loop diagrams in Bhabha scattering”. Co-supervisor: Prof. M. Wilkens

A. Krüger, Diploma thesis (Humboldt-Universität zu Berlin 1998): ”Vorhersagen für Effekte schwerer neutraler Eichbosonen am $ep$-Beschleuniger HERA”. Co-supervisor: Prof. D. Ebert

I gave many talks at schools and conferences. A collection of them, as well as of some software projects, may be found at my webpage at DESY:
http://www-zeuthen.desy.de/~riemann

2015

A selection of my present scientific interests has been described. A rather complete ”List of publications“ is attached to this CV.

In addition, there is renewed interest in some older projects, where I try to give some support to actual users, but do not perform new research.

This concerns the ZFITTER software. I get a permanent flow of questions, specifically from PhD students who want to apply it. ZFITTER was intended for the $Z$ boson resonance.

But now the meson factories are getting extremely precise, and the Belle II experiment in Japan plans to measure the $\gamma Z$ interferenz for muon pair production at about 10 GeV with a precision of about 1%. This enables them to measure the so-called $\rho$ parameter with highest precision, and thus to search also for New Physics. For the analysis they plan to use ZFITTER due its unique properties for data fits.

Also at Belle II, the extra-ordinary accuracy of their muon pair data might deserve software tests. Belle people intend to use besides ZFITTER the KKMC project of the Krakow group (S. Jadach et al.). Here, our topfit project (2003) can become interesting too, because it is a complete electroweak exact NLO (semi-)analytical calculation of massive fermion pair production, and thus useful as an etalon. This would deserve a bit additional programming effort, though. Belle II needs, of course, also QED higher orders as available in KKMC.

From the Fcc-ee project, there is interest in a study of applicability of the S-matrix approach to the $Z$ boson peak, aiming at a $10^{13}$ sample. Here, the combined use of SMATASY/ZFITTER might be needed.

My research term at DESY will finish with retirement in November 2016. I plan to stay active, without funding, for at least another two or three years.

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