STARTPAGE

PEOPLE
MARIE CURIE ACTIONS

Intra-European Fellowships (IEF)
Call: FP7-PEOPLE-2009-IEF

PART B

“BSMTOOLS4LHC”

Table of Contents

B1 SCIENTIFIC AND TECHNOLOGICAL QUALITY

Scientific and technological quality, including any interdisciplinary and multidisciplinary aspects of the proposal

The coming decade will be an exciting era of modern high energy physics. Run II at the Tevatron collider is now well underway and has already produced more than fifty times the amount of data that was used in discovering the top quark; first events for the Large Hadron Collider are now expected for early 2010. The study of hadron collisions at the TeV scale will provide us with a unique chance to answer a longstanding fundamental question: What is the exact nature of the mechanism responsible for the observed electroweak symmetry breaking? In particular, it will allow us to draw definite conclusions about the existence of the Higgs particle predicted by the successful Standard Model (SM) of particle physics.

Various theoretical and observational considerations suggest that the particle and symmetry content synthesized in the SM may not be the full story. The so-called “hierarchy problem”, in particular, implies that new physics should show up around the TeV scale in order for the Higgs boson mass not to be unnaturally fine-tuned. Though the nature of this “new physics” is still to be determined, it is probably closely linked to already known heavy particles like the W and Z bosons or the top quark. Recent experimental results that cannot be accommodated by the SM, like non-zero neutrino masses and the large amount of dark matter inferred from astrophysical observations, may be important hints for the presence of unknown particles and interactions, close to the electroweak scale of about 0.1 TeV.

Extracting new physics imprints from existing and forthcoming hadron collider experiments is going to be a real challenge, both from the theoretical and the experimental point of view. This is due, in part, to the enormous amount of data to be analysed, but also to the intrinsic complexity of hadron collisions. In particular, any definitive identification of “Beyond the Standard Model” (BSM) signatures will directly rely on an accurate characterization of the signature itself in order to define winning strategies to isolate it, and to subtract the potentially large underlying background.

Parton-level Monte-Carlo simulations
High energy Monte-Carlo event generators first produce “parton-level” events. They correspond to the specification of all the four-momenta associated with the final state “partons”, which are fundamental particles like quarks, gluons, leptons, photons, ... These variables are statistically distributed, according to known scattering amplitudes and initial state parton kinematics, which, in turn, are described by experimentally determined “parton distribution functions”.

The accurate numerical simulation of both signal and background events using Monte-Carlo techniques has been a very active field of research for the past twenty years. Multi-purpose event generators based on parton shower techniques have been successfully used to simulate various type of high energy interactions at the LEP, HERA and Tevatron colliders. More recently, parton-level event generators based on leading order and next-to leading order matrix elements have also been used

Parton shower vs. Matrix Element based simulations

Parton shower based generators simulate high energy events using “chains” of successive decays and radiation emissions. This method is intrinsically efficient to describe soft and/or collinear emissions of partons, and is easily interfaced with hadronization models. However, it fails to reproduce particular features of hard scattering processes. These features are better described by exact matrix elements generated at a given order using standard perturbative quantum field theory techniques, e.g. Feynman diagrams (see Fig. 1). Merging these two approaches inside a consistent framework framework is the subject of much current research because it allows to take advantages from both techniques.

in order to refine the description of the hard core of scattering processes.

Unfortunately, most of these tools were initially designed and developed to simulate mainly SM events. Because of this, the simulation of new BSM processes was, until recently, rather limited by two factors. First, it relied on time-consuming and error-prone modifications of core source files by expert users, who traded off standardization and generality against efficiency of the resulting code. Second, it required the manual derivation of a large number of lengthy algebraic expressions which were typically hard to validate in a systematic and reproducible way.

The situation has been drastically improved recently thanks to the Mathematica package FeynRules, for which the applicant co-developed interface components. This package allows the user to automatically generate the Feynman rules associated to an arbitrary theory. However, contrary to other packages previously developed to achieve the same goal, FeynRules is not restricted to a specific Monte-Carlo generator and can be interfaced to any of them. Such interfaces already exist for various programs, and others are foreseen in a near future. Due to this particularity, and its user-friendly nature, FeynRules appears as the key element of a more general scheme where any new physics model can be developed, validated and tested against data (see Fig. 2). The power, robustness and flexibility of this approach has already been demonstrated over the past few months by the actual implementation and automatic validation of several new physics models. One can foresee such a scheme to not only considerably lower the amount of technical efforts to test the consequences of a new theoretical idea, but also to provide unprecedented opportunities for cross-disciplinary exchanges between theorists and experimentalists, thus solving issues (model conventions, software traceability, ...) previously faced, for example, during the Tevatron new physics searches.

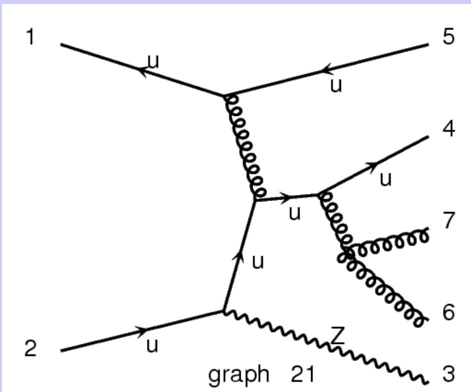

Fig. 1. One Feynman diagram generated automatically by the MadGraph program, among the 36320 required for the accurate simulation of a Z boson plus four jets event.

Being the starting point of this global and efficient framework , the FeynRules approach also shows up possible limitations in other elements of the simulation chain, going from a theoretical idea to its experimental signatures. The most important ones are related to restrictions of the matrix element generators themselves which are not, or only very partially, able to deal with various new structures encountered in complex BSM models. This is particularly true when considering, for example, generalized Lorentz structures, non-renormalizable vertices and arbitrary color representations. Furthermore, it should be noted that many of these limitations have been noticed not only by developers themselves, but also by several end-users of the quoted applications.

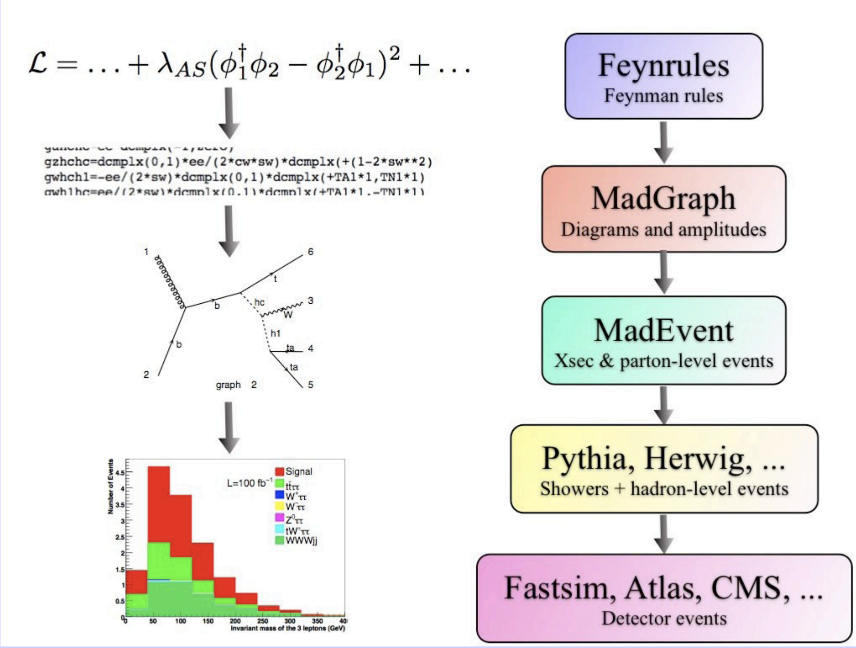

Fig. 2. Illustration of a software chain (in this case, using the MadGraph/MadEvent generator) allowing high energy physicists to quickly go from a theoretical idea, i.e. a Lagrangian, to its experimental signature, i.e. reconstructed events in a detector. Intermediate steps that can now be automatically dealt with, like Feynman rules and Feynman diagrams, are also displayed.

In this context, I propose to define research objectives along two main directions:

1. To *develop* a new matrix element generator designed specifically to address the difficulties related to complex BSM theories, employing the latest techniques for efficient simulation of complex final states, and such that it can be interfaced with external tools for the automatic generation of next-to-leading order matrix elements.

2. To *apply* this new tool, together with existing ones, for developing and assessing the feasibility of new techniques for (model independent) new physics signal searches.

Both research objectives possess strong interdisciplinary aspects. The proposed design and development of a new matrix element generator will require inputs from various members of the High Energy community including BSM model builders, perturbative (leading and next-to leading order) QCD experts and Monte-Carlo program authors. Furthermore, the actual use of this new tool to define new methods for BSM physics searches will also require a very close collaboration with various experimentalists in charge of data reconstruction and analysis.

Research methodology

Design and development of a new matrix element generator called “MadGraph v5”

The “MadGraph v5” application will inherit various features of the successful matrix element generator now part of the MadGraph/MadEvent v4 project, in which the applicant is currently involved. This project followed the earlier development of the original MadGraph program, which was the first tool to automatically generate Feynman diagrams along with the associated tree-level helicity scattering amplitudes for arbitrary processes, and of the MadEvent Monte-Carlo generator, which makes use of the matrix elements produced by MadGraph to truly simulate parton-level events.

The proposed project goes far beyond a simple “new release” of the MadGraph program since a complete re-writing is envisaged. First, this re-writing appears to be necessary in order to guarantee the future of the successful MadGraph/MadEvent application used regularly by hundreds of HEP physicists, and which might be (in the long term) compromised by maintenance and scalability issues. Second, it will allow the implementation of unprecedented new features which would have been impossible to develop in the context of the existing code. The ambitious new features to be developed include:

1. *New Feynman diagram generation algorithm* specifically designed for complex BSM signal simulation. This new algorithm will employ the whole model information to generate diagram topologies more efficiently and should drastically reduce computation time for processes with many particles in the final state.

2. *Generic treatment of color* structure to allow the simulation of BSM processes involving exotic colored particles and/or new vertex structures.

3. *Extended possibilities for final state and decay chain specifications*, e.g., signature based, all relevant processes and decay modes for a given model at a given collider, ...

4. *Compatibility with a new external library for helicity amplitude calculation* where the arbitrary Lorentz structure appearing in various BSM models can be implemented in an automatic way, e.g., using the FeynRules package.

5. *Efficient treatment of multi-gluon final states* using modern techniques like recursion relations whenever possible. The use of pre-calculated information which can be “recycled” for other processes is also envisaged.

6. *Automatization of NLO calculations,* including tree-level and one-loop amplitudes as well as implementation through subtraction techniques.

7. *Complete parallelization of the code* to take full advantage of available computer resources.

8. *Modular and re-usable code* designed as a user-friendly development environment for future applications. In particular, the internal representation of the resulting Feynman

diagrams and matrix elements will be abstract enough to ensure an easy conversion to any format required by specific usages (i.e., not only the MadEvent application).

9. *A completely new code structure*. The main code will be written in Python, a high-level programming language with interesting advantages for HEP applications. Comparing to Fortran 77 (the current language used for MadGraph), it provides object orientation, easy prototyping and comes with various advanced libraries for routine operations. Comparing to other object-oriented languages used in the HEP community, like C++, it provides simpler syntax, dynamical typing, higher-level data types, more compact code, automatic memory management and powerful unit testing. The main disadvantage is a lower speed for numerical applications. However, a lower-level programming language like Fortran 95 or C can be used for the few speed critical parts of the code.

Objectives 1, 2, and 3 will be developed mainly by the applicant in the context of this proposal. Objectives 4, 5 and 6 will be co-developed in collaboration with external collaborators, as well as the more technical objectives 7, 8 and 9 (with the help of local IT staffs). Overall, the whole project will be under the applicant's constant supervision.

The development methodology will take advantage of the proposed modular structure. After a first design phase needed to structure the application as a whole, every new feature will be conceived, developed, tested and validated as a self-standing module, independently of the others. This approach, close to the so-called "agile" software design technique, contrasts with the traditional "monolithic" structure of HEP applications and will allow developers to focus on the resolution of physics problem instead of having to worry about technical issues (solved by the use of common internal and external libraries) or the actual integration of new features. The proposed developments will guarantee the possibility to further develop the code in the future, and will strengthen considerably its position among the leading HEP applications in the coming years.

<u>Development of innovative methods for new physics signal searches at the LHC</u>

Taking advantage of the proposed development of a new matrix element generator with unprecedented capabilities for the simulation of BSM processes, I propose to investigate the feasibility of two original methods for model independent new physics signal searches at the LHC:

1. The use of evolutionary algorithms to build, through an iterative optimization process, a set of discriminant distributions maximizing the significance of possible "anomalies" appearing in an inclusive set of data (e.g., all events containing three muons). Since this method makes intensive use of Monte-Carlo data as a reference, it can be first employed to assess the quality of the simulated samples, and only then applied to real new data to achieve the

Evolutionary algorithms
Evolutionary algorithms are population-based optimization algorithms using mechanisms inspired by biological evolution: reproduction, mutation, recombination and selection. They have been introduced in the 70's and used successfully since then in various fields, ranging from robotics to finance. In computer sciences, they have been used recently to impressively demonstrate the possibility for a well-programed automate to deduce simple physics laws from noisy chaotic pendulum data.

detection of possible new physics signatures. The algorithm to be used, i.e., a genetic programming technique, is known to converge more quickly than other methods (neural networks, ...) when applied to complex optimization problems. There are of course possible issues associated with this technique, e.g., the presence of false minima in the efficiency evaluation procedure leading to a possibly under-evaluated significance of a specific anomaly. Those will be carefully checked and their importance assessed in the present context of broad range model independent searches.

2. The amelioration of existing ideas for the automatic simulation (and comparison with data) of BSM "scenarios" using multi-purpose event generators. An common criticism of such techniques is the lack of restriction and the plethora of signature possibilities to test against the data, even for simple models. I propose to again address this issue using an evolutionary computing technique. Instead of generating blindly all possible signatures associated to a given set of particles/interactions, the best potential candidates will be first selected and then allowed to "evolve" only if they manage to reproduce, even partially, some specific feature observed in the data. The application of the very same technique to the evolution of the model content itself is also envisaged in order to address, as generically and unbiasedly as possible, the so-called "LHC inverse problem".

The "LHC inverse problem"
The so-called "LHC inverse problem" refers to the practical possibility (or impossibility) to determine the TeV Lagrangian and the underlying theory corresponding to an hypothetical new physics signal visible at the LHC. More specifically, it sometimes also refers to the extraction of physical parameters (masses, coupling values, ...) from experimental data, assuming a certain model. Up to now, no completely satisfying solution has been found to solve those issues, which are however crucial for the success of the LHC experiment.

The research methodology will be divided into three phases. First, the required evolutionary algorithm methods will be designed, implemented and tested to assess the feasibility of method 1 when applied to Monte-Carlo samples of increasing complexity (from parton-level to reconstructed events, without and with background, ...). Once the feasibility of this method is established, and its possible advantages/limitations mapped out, its application in the context of real data analysis (possibly with the first real data from the LHC) will be investigated in cooperation with experimental collaboration(s). Finally, application of evolutionary methods to the automatic generation of BSM scenarios (method 2) will be investigated once the required tools (mainly objectives 1-5 of the MadGraph v5 development plan) will be ready.

Originality and innovative nature of the project, and relationship to the 'state of the art' of research in the field

The original and innovative nature of the development part of this project is ensured by the necessity to implement new solutions to solve known problems in the very broad context of arbitrary BSM theories, yet keeping the resulting code efficient enough for realistic applications. For example, existing methods for Feynman diagram generation and color coefficient calculations are in general well-suited for typical SM processes, but often scale very badly with increasing model complexity and/or new types of particles/interactions (e.g, Majorana fermions, new color representations, ...). The implementation of other high-end new features (objectives 3 to 5) will also require the development of new concepts/ algorithms to ensure applicability in the context of arbitrary BSM models.

Regarding the development of new methods for new physics signal searches at the LHC, the proposed solutions are intrinsically original and innovative since evolutionary selection methods have, up to now, only been used for limited applications in HEP, and never in the context of BSM signal analysis.

As a whole, the proposed project clearly aims at being on the cutting-edge of existing efforts in the field to produce reliable tools for new physics simulation, detection and characterization at the LHC. Even though serious competitors exists, especially in the context of SM signal simulation, I expect the proposed tool, i.e., MadGraph v5, to have enough qualities and new features to be at least as welcomed and widely used by the community as its predecessors. In the context of automatized BSM signal searches, I also hope the two methods proposed in the present application will offer a credible starting point to address the long standing “LHC inverse problem”.

Timeliness and relevance of the project

Both the timeliness and relevance of the proposed project are mainly related to its direct usefulness for the Large Hadron Collider, the world largest fundamental science experiment in which the EU scientific community is crucially involved.

The LHC experiment has been thought and designed as an unprecedented probe of the TeV scale. As such, its main goal beyond the detection of the elusive Higgs boson predicted by the Standard Model is to identify, and possibly characterize new physics at this scale. However, as already emphasized earlier, in many cases such achievement will only be possible if one can simulate efficiently, quickly and flawlessly a large variety of signal processes to define isolation strategies. Even though considerable progress has been made in this direction in the past decade, I believe the completely generic, BSM oriented, matrix element generator described in the present proposal remains a missing element to fully achieve this ambitious goal. The development of this innovative tool will clearly profit to a very large community of HEP physicists, from theorists to experimentalists involved in data analysis.

Along the same line, the proposed methods for BSM signal searches based on evolutionary algorithms will also provide, if their feasibility is actually assessed, a new way to efficiently extract information from the produced data without any assumption on the underlying theory. Once a specific anomaly is detected, they could even help in automatically characterizing the observed new physics, thus solving at least partially the LHC inverse problem.

The present proposal can also be considered to be particularly well-timed, since the LHC experiment is currently expected to produce its first physics results in 2010 after a beam injection test period planned by mid-November 2009. Assuming a starting date for the proposed project in the first half of 2010, the first version of MadGraph v5 could be available for the very first complex BSM signal searches expected around 2011. The same is true for the development of a new anomaly detection method which should be ready for the analysis of early data coming after the detector calibration phase.

Finally, through intensive collaborations with researchers from other member states of the European Union (in particular Belgium, Italy and the UK), the proposed project will clearly strengthen links with the European physics community for both the researcher and the host institution.

Host scientific expertise in the field

The Nikhef institute proposed as a host is the national centre for particle physics in the Netherlands, coordinating all Dutch activities in this field. The institute has several large experimental groups involved in the LHC experiments, i.e., ATLAS, LHCb and ALICE, but also develop various activities related to astroparticle physics. The theory group, which will host the applicant, consists of 6 staff, 6 postdocs, 6 PhD students and various master and bachelor students. It maintains close links with the experimental groups and their research effort, links which will even be reinforced by the applicant in the context of the present proposal. This is particularly true in the context of BSM physics searches which is a strong point of the ATLAS group, thanks, for example, to a recent “Vici” grant of the Netherlands Organisation for Scientific Research (NWO) awarded to Nikhef-ATLAS staff member Paul de Jong for SUSY particle searches.

Theorists at Nikhef participate in collaborations with colleagues from institutes in Europe (Cambridge, Turin, CERN, Liverpool, Madrid, DESY-Zeuthen, Louvain, etc.), the US (Stony Brook, Brookhaven, UIUC, etc.), India (Chennai, Bombay) and Japan (KEK). The scientist in charge, E. Laenen, has a renowned expertise in perturbative QCD and more generally in collider phenomenology (E. Laenen and D. Wackeroth, Annual Review of Nuclear and Particle Science 59 (2009)) which will be particularly valuable in the context of the present proposal. Other theory department members, like D. Forde and T. Reiter, are strongly interested in automatic NLO calculations and are already involved in collaborations (BlackHat, Golem) working in this direction. Their experience will be particularly valuable for the present project. Finally, various members of the theory department have been involved in the development/extension of Monte-Carlo tools like MC@NLO (e.g., see S. Frixone, E. Laenen, P. Motylinski and B.R. Webber, “Single-top production in MC@NLO”, JHEP 0603 (2006) p092) or in the creation of the widely use d algebraic manipulation software FORM (e.g., see J.A.M. Vermaseren, “New features of FORM”, math-ph/0010025).

Quality of the group/supervisors

The theory group at Nikhef has a distinguished record in training early researchers. In the past 10 years, 11 postdoctoral scientists have been educated at Nikhef. Almost exclusively, these postdocs have joined the group immediately after obtaining their PhD. Of these 11 postdocs, 7 have since obtained permanent or semi-permanent academic positions in other institutions.

Nikhef has a well-established outlets for academic training at all levels. The theory group holds a monthly meeting involving researchers from around the Netherlands, consisting of short seminars and informal discussions about current research. Regular “theory seminars" are also organized (every other week since January 09), where scientists from all over the world are invited to share their expertise on a specific subject. In parallel, the group holds internal "journal club" meetings where the most recent progresses in HEP theory are informally discussed. All these activities are very well attended and give an excellent opportunity for researchers, from students to staff members, to meet colleagues, then discuss and develop new ideas.

B2 Training

Clarity and quality of the research training objectives for the researcher

The research training objectives of the project can be summarized as follow:

1. *Acquisition of knowledge of advanced topics in BSM phenomenology (especially non-standard Higgs physics), quantum chromodynamics LO and NLO calculations, Monte-Carlo simulation and computational physics*. These are valuable additions to the applicant's current expertise, and geared very much towards a direct involvement with the coming generation of particle physics experiments. Those subject areas will lead easily to future research opportunities after the proposed project has terminated, and will significantly broaden the applicant's area of expertise. For example, an improved knowledge of various QCD computational methods at leading and next leading order, besides being directly and indirectly required by the present proposal (e.g., see objectives 2, 5 and 6 of the research methodology), will be of direct usefulness in the more general field of hadron collider phenomenology.
2. *Development of inter-disciplinary communication and adaptation skills in the context of collaborations with large experimental teams.* This training objective is directly related to requirement of a "closer than ever" collaboration between the theory and experimental communities in order to extract fundamental knowledges from the coming collider data. The applicant will learn how best to tailor his research to the needs of the experiments where its applied, in the context of both the proposed new software and new analysis methods development. Those skills will clearly help to consolidate his phenomenology orientation.
3. *Experience in managing research projects with well-defined goals, resources and timescales*. The researcher achievement record already shows successes in the management of various research projects. Nevertheless, he will need to further develop his ability to define, structure and lead the efforts required to achieve the proposed objectives with fixed deadlines in the context of collaborations with other members of the MadGraph development team and experimental groups. These new management skills will clearly serve the applicant in future projects and are necessary in achieving the transition from early researcher to fully independent scientist.
4. *Enhancement of computational skills, in particular regarding large-scale software design and development methodologies*. The proposed project requires various advanced computational skills including: the Python programming language, advanced software development techniques like unit testing and error management, and robust and modern design method like, for example, "extreme programming". It also require a good knowledge of problem solving using evolutionary methods. Many of these skills seems promising (as testified by successes in other fields) but are currently only poorly

represented among the HEP community members and being among the firsts in mastering them will possibly give an advantage for the researcher future career.

Relevance and quality of additional scientific training as well as of complementary skills offered

In addition to the research skills specified in the previous section, the proposed project aims to provide the following complementary training:

1. *Preparation of conference talks, scientific papers, technical reports and manuals for developed computer softwares.* The researchers will be expected to systematically and regularly communicate his results and methods to the scientific community through standard means (publications in peer reviewed journals, notes, conference talks, lectures, ...) but also through other modern medias like interactive websites. This will allow him to further develop his communication skills, both as an independent researcher and a member of middle-size collaborations.
2. *Development of communication and management skills specifically oriented towards user support*. Experience has shown that the long-term success of HEP softwares and analysis methods implementations, besides their intrinsic scientific quality, is also very dependent of their actual use by the community, which is itself closely linked to the amount/quality of user support provided by the authors. In parallel with the proposed new developments, the applicant will thus pay particular attention to end-user feedbacks.
3. *Assistance in the training of students and early researchers.* Besides the support to the community detailed above, the applicant will also be expected to provide more specific feedback and/or mentoring to one or more PhD students in the host institution, regarding the proposed project but also for more general questions related to collider phenomenology. As well as providing a valuable service to the host institution, this will be a useful first experience for future supervisions.

Host expertise in training experienced researchers in the field and capacity to provide mentoring/tutoring

Nikhef is a sizable particle physics laboratory with more than 50 permanent scientific staff, around 10 postdocs and many more PhD students and technical staff. Thus, the host institution has had ample experience in training early researchers. The theory group also has extensive experience in this regard. Besides the successful mentoring of 11 postdocs in the past 10 years, about 15 PhD students obtained their doctorates in the theory group. The mentoring and tutoring of experienced researchers in the Nikhef theory group takes place in a number of ways: by involving them in equal partnership in international collaborations (typically up to 4 or 5 members) on challenging research questions, but also allowing them to follow their own research ideas if worthwhile; by encouraging them to present their work both nationally and internationally; by involving them in international workshops, and sending them to conferences; by stimulating their attendance of topical lecture series. PhD students and postdocs have found prestigious follow-on positions, e.g. at Cambridge, Fermilab, Columbia U., Brussels and Durham.

More specifically, the supervisor has ample experience in tutoring and mentoring young researchers. In fact, of the 7 postdocs that have obtained permanent positions, 3 (S.

Weinzierl, S. Moch, A. Banfi) were supervised by Laenen. Present postdoc and IEF fellow, C. White, has also been supervised by Laenen. He will soon move to a world-class institute in Durham (UK), having profited considerably from opportunities provided by Nikhef. In the period mentioned Laenen has also successfully supervised 5 PhD students, as well as a large number of master students. At present Laenen is moreover the group leader of the theory group, holds a full professorship at the University of Amsterdam, and is in addition the PI of a national research program centered around theoretical particle physics in the LHC era. In these roles he has in particular an eye for ensuring that young researchers from Nikhef and other Dutch university groups are productive, and communicate with each other, .e.g through monthly meetings at Nikhef.

B3 Researcher

Research experience

The researcher has the following curriculum vitae:

Education and work:

Postdoctoral researcher in the Theory Group — Present
Nikhef, Amsterdam, the Netherlands

Doctorat en Sciences, orientation Physique (PhD in Physics) — Sept. 2008
Université catholique de Louvain, Louvain-la-Neuve, Belgium, Dissertation entitled “A two-Higgs-doublet model: from twisted theory to LHC phenomenology” supervised by Prof. J.-M. Gérard

Diplôme d'Etudes Approfondies en Sciences Physiques — June 2004
Université catholique de Louvain, Louvain-la-Neuve, Belgium

Licence en Sciences Physiques (Master in Physics) — June 2003
Université de Mons-Hainaut, *Mons, Belgium*, Final dissertation entitled “An approach of string theory on BTZ black holes” supervised by Prof. Ph. Spindel - La plus grande distinction et les félicitations du Jury

Seconde Candidature en Sciences Physiques (Bachelor in Physics) — June 2001
Université de Mons-Hainaut,
Grande distinction

Première Candidature Ingénieur Civil — June 2000
Faculté Polytechnique de Mons, *Belgium*
Grande distinction

Secondary School — June 1999
Institut de la Sainte-Famille, Mons, *Belgium*
Options: Mathematics, Science and English

Awards, Prizes and responsabilities

- Elected representative of the temporary scientific members of the Physics department (2004-2007)
- Belgian Physical Society prize for the best master's thesis (2004)
- Lauréat Olympiades Belges de Physique (1999)
- Lauréat Olympiades Belges de Chimie (1998 and 1999)

Teaching & Outreach Experience

- Support for exercise sessions of the course “Quantum Field Theory” at the UvA, January to June 2009, Amsterdam, the Netherlands
- Two lecture sessions on Higgs Physics at the LHC for the “Samedis de la Physique” outreach program (2008), Brussels, Belgium
- Master Classes in Particle Physics outreach program at UCLouvain (2004-2006)
- Teaching assistant at the UCLouvain from September 2003 to September 2008 (approx. 200h/year, from Physics for 1st year Biologists to Advanced Quantum Mechanics for 3rd year Physicists)
- Various physics courses for secondary school students (2000-2003)

Seminars, talks and lectures (25)

- *Unconventional phenomenology of a minimal two-Higgs-doublet model*, talk, September 2009, Workshop on Multi-Higgs Models, Lisbon, Portugal (scheduled)
- *MadGraph/MadEvent, Status, results and prospects*, talk, May 2009, MC4LHC training event, CERN, Switzerland
- *MadGraph/MadEvent (Recent) Past, Present & Future*, talk, March 2009, LHC Focus Week, IPMU, Japan
- *Exotic two-Higgs-doublet model & associated signatures at the LHC*, talk, June 2008, Theory meeting, Nikhef, The Netherlands
- *The hunt is on: Strategies, challenges and prospects for Brout-Englert-Higgs boson(s) searches at the dawn of the LHC era*, session opening talk at the annual Belgian Physical Society meeting, May 2008, ULB, Bruxelles, Belgium
- *MG/ME for photon physics at the LHC*, talk, April 2008, High energy photon collisions at the LHC Workshop, CERN, Switzerland
- *A Les Houches Interface for BSM Generators*, talk, March 2008, MC4BSM Workshop, CERN, Switzerland
- *MadGraph/MadEvent v4: Building bridges between theory(ies) and experiment(s)*, talk, February 2008, ATLAS MC group, CERN, Switzerland
- *MadGraph/MadEvent v4: Building bridges between theory(ies) and experiment(s)*, talk, February 2008, LCG, CERN, Switzerland
- *MadGraph v4.1: Hands-on session*, lectures, January 2008, YETI 2008 (school for graduate students), Durham, UK
- *Twisted Higgs Phenomenology at Hadron Collider*, talk, November 12th 2007, EURO-GDR SUSY 2007, Bruxelles, Belgium
- *Twisting Higgs Phenomenology at Hadron Collider*, Seminars, September and October 2007, USA:
  - Princeton University (Princeton, September 11th)
  - University of Illinois at Urbana-Champaign (Urbana, September 13th)
  - University of Chicago (Chicago, September 17th)
  - Argonne National Laboratory (Darien, September 24th)

  - Fermi National Laboratory (Batavia, September 26th)
  - Berkeley University (Berkeley, October 1st)
  - University of California at Davis (Davis, October 2d)
  - Stanford Linear Accelerator (Stanford, October 3rd)
- *Introduction to MadGraph/MadEvent*, lecture given at CAPP2007 (school for graduate students), March 2007, DESY Zeuthen, Germany
- *The two-Higgs-doublet model implementation in MadGraph/MadEvent v4*, talk given at MC4BSM workshop, March 2007, Princeton, USA
- *The new MadGraph/MadEvent v4: from models to detectors in one go*, talk, February 2007, ULB, Bruxelles, Belgium
- *An not so short introduction to MadGraph/MadEvent v4*, three lectures at the HELAS/ MadGraph/MadEvent school, October 2006, KEK Theory division, Tsukuba, Japan
- *MadGraph/MadEvent 4.0: New tools for New Physics*, talk given at SUSY Tools 2006, June 2006, LAPTH-LAPP, Annecy, France
- *Custodial symmetry in extended scalar sectors*, talk given at IAP meeting, June 2004, KUL, Leuven, Belgium

Attended international conferences and workshops (12)

- Workshop on Multi-Higgs Models, September 2009, Lisbon, Portugal (scheduled)
- MadGraph/MadEvent meeting, September 2009, Louvain, Belgium (scheduled)
- MC4LHC: from Parton Showers to NNLO, training event, May 2009, CERN, Switzerland
- LHC focus week meeting at IPMU, March 2009, Kashiwa, Japan
- YITP workshop, March 2009, Kyoto, Japan
- Monte Carlo Tools for Beyond the Standard Model Physics workshop, March 2008, CERN, Switzerland
- Les Houches 2007: Physics at TeV Colliders, June 2007, Les Houches, France
- Computer algebra and particle physics 2007, March 2007, Zeuthen, Germany
- Physics at the LHC and Monte Carlo Tools for Beyond the Standard Model Physics workshops, March 2007, Princeton, USA
- HELAS/MadGraph/MadEvent workshop, October 2006, Tsukuba, Japan
- Tools for SUSY and the New Physics workshop, June 2006, Annecy, France
- SUSY 2005, July 2005, Durham, UK

Publications (7)

- A comprehensive approach to new physics simulations, N. Christensen (Michigan State U.), P. de Aquino (UCL/KUL), C. Degrande (UCL), C. Duhr (UCL), B. Fuks (U. de Strasbourg), M. Herquet (Nikhef), F. Maltoni (UCL), S. Schumann (U. Heidelberg), *To be submitted for publication* (2009), arXiv:0906.2474
- *Unconventional phenomenology of a minimal two-Higgs-doublet model*, S. de Visscher (UCL), J.-M. Gérard (UCL), M. Herquet (Nikhef), F. Maltoni (UCL), V. Lemaitre (UCL), *Accepted for publication in JHEP* (2009), arXiv:0904.0705
- *MadGraph/MadEvent v4: The New Web Generation*, J. Alwall (Stanford U.), P. Demin (UCL), S. de Visscher (UCL), R. Frederix (UCL), M. Herquet (UCL), F. Maltoni (UCL), T. Plehn (U. of Edinburgh), D. L. Rainwater (U. of Rochester) , T. Stelzer (U. of Illinois at Urbana-Champaign), *JHEP 0709, 028 (2007)*, arXiv:0706.2334
- *A twisted custodial symmetry in the two-Higgs-doublet model*, J. M. Gerard (UCL) and M. Herquet (UCL), *Phys. Rev. Lett. 98, 251802 (2007)*, arXiv:hep-ph/0703051

- *Is V(tb) = 1?*, J. Alwall (UCL), R. Frederix (UCL), J.-M. Gerard (UCL), A. Giammanco (UCL), M. Herquet (UCL), S. Kalinin (UCL), E. Kou (UCL), V. Lemaitre (UCL) and F. Maltoni (UCL), *Eur. Phys. J. C 49, 791 (2007)*, arXiv:hep-ph/0607115
- *A new look at an old mass relation*, J. M. Gerard (UCL), F. Goffinet (UCL) and M. Herquet (UCL), *Phys. Lett. B 633, 563 (2006)*, arXiv:hep-ph/0510289
- *Global geometry of the 2+1 rotating black hole*, P. Bieliavsky (ULB), S. Detournay (UMH), M. Herquet (UMH), M. Rooman (ULB) and P. Spindel (ULB), *Phys. Lett. B 570, 231 (2003)*, arXiv:hep-th/0306293

Research results

Up to now, the applicant major achievements are:

1. In the context of his PhD thesis, and under the supervision of his advisor, the applicant identified a new degree of freedom in the definition of the custodial symmetry in the context of the general two-Higgs-doublet model (2HDM). Taking advantage of this additional freedom, he developed a new minimal, yet unusual, realization of the generic 2HDM, featuring naturally an inverted Higgs mass spectrum contrasting with, for example, the one associated with the Minimal Supersymmetric SM. After having extensively reviewed all the relevant theoretical, indirect and direct constraints in this context, the applicant described, in direct collaboration with experimentalist colleagues, various original and promising signatures of this model at the LHC and rigorously proved its discovery potential. This long-term project, which lasted from 2004 to 2008, led to various original results published in the most renowned journals of the field and presented in several occasions in leading institutions in the EU and in the USA. In each case, the applicant's skills relating to communicating, elucidating and discussing scientific ideas were honed. It also allowed him to develop skills and knowledges in various fields such as exotic Higgs physics, model building, precision electroweak and B meson physics constraints, and collider phenomenology. Finally, it led the applicant to manage profitable inter-disciplinary collaborations between theorists and experimentalists, giving rise, for example, to various new projects currently developed in PhD and master thesis.
2. In parallel with his study of exotic scalar sectors, the applicant has also been deeply involved in the development of the MadGraph/MadEvent v4 event generator. This involvement was initially limited to the implementation of the most generic 2HDM in MG/ME but quickly became more important. For the official release of the fourth version, the applicant has been specifically in charge of all aspects related to BSM model implementation, but also of many other technical aspects related to online generation, parallel calculations, code management and user support. Besides the code itself, now used regularly by hundreds of HEP theorists and experimentalists, and officially by the CMS collaboration, the first result of this involvement was a (now very well-known) publication in a renowned journal in 2007, promptly followed by several invitations to giving talks, tutorials and even lectures at schools in several countries. The commitment of the applicant for user support has also been recognized by several personal acknowledgments in papers presenting results obtained using MG/ME v4. Recently, the applicant received the primary responsibility for the new developments related to BSM model implementation in the existing and future MG/ME code. In this context, he also co-authored the corresponding interface for the FeynRules package as

well as new version of the widely used USRMOD package for new model implementation, both released publicly and described in a publication in June 2009.

Besides those main achievements, the applicant participated to other side projects related, for example, to fermion mass matrices or top quark physics. As for the other achievements, those project led to publications in renowned journals for which the applicant shared responsibility for the writing of the manuscript.

Independent thinking and leadership qualities

In the context of his main PhD project, the applicant decided early-on, as a theory group graduate student, to initiate a collaboration with members of the experimental group of his institute. The nature of this collaboration, aimed to elucidate the visibility of some of the unusual collider signatures of the model he was developing at that time, has been defined by the applicant himself. It culminated in the publication of a paper for which the applicant was primary responsible for the writing of the final manuscript and setting the timetable for the completion of the project. This fruitful collaboration not only deeply influenced the direction of the applicant's thesis but also gave him the opportunity to develop his communication skills in the context of a long-term, truly inter-disciplinary project.

Through his involvement in the MadGraph/MadEvent development team, the applicant also had opportunities to develop independent thinking and leadership qualities. Involved in the early stages of the version 4 development in 2006, he took part in various decisions that impacted the current structure and features of the code. Since then, he has been a full-fledged member of the team and had received various responsibilities, including, for example, new model implementation, parallel computation features and code management. He has also been invited to present several talks, tutorial and lectures about the latest features of the MadGraph codes in various conferences, schools and institutes all over the world. This allowed him not only to notably improve his communication skills in rather short period of time, but also to weave a quite large contact network in the international HEP community. The future developments proposed here will not only help the applicant to improve furthermore its independent thinking, but will also give a great opportunity to develop its leadership capabilities in the context of a project for which he will share the highest responsibilities.

Whilst at his present institution, the applicant has inherited joint responsibility for the organization of seminars for the theory group. This consists of a regular series of one hour talks by researchers external to the group, often from abroad. Sometimes, when the talk subject is particularly oriented towards phenomenology, experimental colleagues are also invited to attend the seminar in order to reinforce links with the theory department. The applicant has been responsible for the recruitment of candidates, liaising with colleagues, setting a timetable for presentations, booking appropriate facilities and arranging practical details of the visit.

Outside his research activities, the applicant also often participated to a various outreach and/or educational programs aimed to large audiences, from pre-university students (e.g., through HEP "masterclasses") to retired seniors (e.g., the "Samedis de la physique"). He also had the responsibility for numerous exercise/lab classes as a teaching assistant (approx. 200h/year) for first to fourth year students in physics but also in biology, medicine, engineering, ... This gave him the opportunity to practice various pedagogical techniques and experience contacts with large groups of students requiring flexibility, patience and a bit of improvisation.

Based on these experiences, the applicant has proven capacity for conducting independent research, both individually and as part of small or middle-size collaborations. His existing track record of talks and lectures shows an aptitude for interpersonal skills and networking and thus reinforce the likelihood of success of future projects. These skills would certainly be further tested and developed by this proposal, together with the candidate's leadership abilities, already in evidence from the above. Furthermore, the applicant already has experience of working within an international, intra- and extra-European setting.

Match between the fellow's profile and project

The applicant has a strong phenomenological background in high energy physics. His thesis work was directly related to collider phenomenology in the context of BSM theories. An original model was developed, and a large part of the chain of tools needed to examine its phenomenological consequence was implemented by the applicant himself in the context of a larger collaboration. This demonstrated not only his ability to spell out the experimental consequences of abstract theoretical notions, but also a sufficient knowledge of technical and computing aspects to achieve this goal. The level of implication of the applicant in both theoretical aspects of BSM theories and in the creation of new Monte-Carlo tools bodes well for the simultaneous theoretical and technical nature of the proposed project, providing a firm foundation for further skills to be built.

On an interpersonal level, the applicant has demonstrated ability to initiate and take part in collaborations in both local and international capacities. He also often presented results in the form of published papers, various types of verbal presentation and public codes. There is a demonstrated ability in independently instigating research in topics not directly related to his expertise, as well as influencing fellow researchers at junior and senior levels. There is also a record of fruitful collaboration with members of the experimental community. Thus the collaborative, inter-disciplinary and communication aspects of the proposed research fits well with the applicant's profile.

Potential for reaching a position of professional maturity

The present proposal will itself clearly provide the researcher with good opportunities to reach professional maturity. First, it involves a leadership position in a large scale project which might have a important short term impact on the HEP community, in particular by opening unprecedented opportunities for the "real-time" simulation of complex BSM processes at the LHC. Second, as already mentioned, the proposed achievements will require to acquire various new knowledges which will help the applicant to diversify his current profile. Finally, besides having a real potential for model independent searches, the signal isolation method development part of this proposal will allow the candidate to simultaneously develop his knowledge of top-notch analysis techniques and to tighten his links with the experimental community.

The host foresees helping the researcher reach scientific and professional maturity in a number of ways. Firstly, by giving him the opportunity to participate in international collaborations. As detailed elsewhere in this proposal, Nikhef has a strong background in such collaborations, and there is a rich network of links to other institutions already in place which can be used for training purposes. In parallel, the researcher will also be expected to take a leading role in the current internal process aiming at reinforcing the existing links between the theory and experimental groups of the host institution. Second, the applicant will be encouraged to present his works at various meetings, conferences and workshops to reinforce his visibility at the international level. Once again, the host institution has already demonstrated its ability to aid development of the research's capabilities in this domain by securing various trips abroad during the last few months. Finally, the host will involve the researcher in the advising of PhD students working in subject area of collider physics in order to give him the opportunity to practice furthermore his tutoring abilities.

Potential to acquire new knowledge

The proposed research includes a number of research topics outside the previous experience of the applicant. For example, the proposed design and development of a new matrix element generator will require an in-depth knowledge of various advanced concepts in perturbative field theory, in QCD at leading and next-to leading order in particular, which are partially new to the researcher. The potential to acquire new skills in this subject area is thus important, especially considering the high degree of expertise of several members of the host institution including the proposal supervisor. In parallel, the potential to develop further skills in side areas as various as the tutoring of early researchers, oral and written communication or even software design is also high and will have a wide applicability within and outside the academic sector.

Despite the new character of many of these ideas and skills in regards to the applicant, he has demonstrated the potential necessary for their development. His previous research has involved independent efforts, sometimes including largely unassisted development in subject areas previously unknown to him. Thus, there is a demonstrated ability to learn new ideas and formulate well-defined research questions, as well as devise appropriate and effective research methodology within a relatively short time-scale. The applicant's existing computer knowledge has been mainly self-taught since he was a teenager, and he continues to show interest and enthusiasm in developing these skills.

Over the years, the candidates benefited on several occasions from visits to other institutions and/or attended to various conferences, workshops and schools. At several occasions, he used those opportunities to develop his own skills, indulging in enthusiastic discussion with fellow researchers and utilizing their expertise for his own gain. This implies that the applicant is able to interact effectively and productively with colleagues, using such interactions for scientific and personal development. In combination with the applicant's independent learning, this amounts to a high potential for acquiring new knowledge.

B4 IMPLEMENTATION

Quality of infrastructures/facilities and international collaborations of host

The proposal involves work at the theoretical level, but has a large application component requiring reasonably powerful computing resources. The host institution, Nikhef, is fortunate in having many shared workstations available, together with a powerful large scale cluster, as well as appropriate softwares with the required support. The computational demands of the projects should thus be easily met by the currently available facilities.

Regarding the proposed interaction with an HEP experimental group, Nikhef possesses a very strong contingent of the global ATLAS experiment task force, as well as many researchers involved in other high energy experiments. This renders the inter-disciplinary aspect of the present proposal very realistic. Furthermore, the particular nature of Nikhef as a national center for high energy physics ensures a very regular supply of visiting scientists form other institutions in the host nation and other countries, thus increasing considerably the effective knowledge base available to the researcher

Finally, the host institution has a strong record of international collaborations over the years, as evidenced by its publication. All the experimental groups at Nikhef constitute sizable parts of large international research efforts. On the theory side, there are strong links with theory groups within the host nation, other European member states and outside the European Union. Notable recent collaborations involve groups from the UK (Cambridge), Italy (Genoa, Turin), Belgium (Louvain), CERN, India (Chennai, Mumbai), Germany (Zeuthen) and the US (Berkeley). Furthermore, sufficient funds and accommodation solutions are available within the theory group for visitors, allowing collaborators to be hosted by Nikhef, even for long periods if necessary.

Practical arrangements for the implementation and management of the scientific project

Concerning computational resources, the researcher will be allocated a new powerful desktop station and afforded relevant system privileges allowing the development, installation and running of new softwares on the network of computers belonging to the theory group. In parallel, he will also have the opportunity to test newly developed applications on the large-scale local cluster “Stoomboot”. The institute has its own IT officer to assist with technical matters relating to both hardware and software, and the IT department within the host institution is more generally available for detailed enquiries and assistance.

The host institution also intends to involve the researcher in the setting up of an inter-disciplinary working group dedicated to BSM physics, involving members of both the theory group and the Nikhef ATLAS group. The exact nature of this collaboration is still to define precisely.

Feasibility and credibility of the project, including work plan

Firstly, the proposed project is naturally divided into modules, such that progress can be made and reported, even if delays are encountered in certain aspects of the project. Nevertheless, the previous research experience of the candidate and the host institution, together with the foreseen integration of the project in the context of an existing, robust and dynamic collaboration, suggest that the timescale of the proposal, which is seemingly very ambitious, is accurate and sufficient. In providing a more detailed work plan, it is convenient to take each research objective of section B1 and identify smaller well-defined subgoals of which each is comprised, each with a reasonable timescale and means of assessment whether a subgoal has been reached.

Design and development of a new matrix element generator (less than 24 months)		
Subgoal	**Timescale**	**Assessment Criteria**
Redaction of an abstract design plan for the new application based on essential physics requirements	2 weeks	Design plan
Selection of existing technologies which best fit the design plan (language, external libraries, versioning system,...)	3 weeks	Technical design report
Choice of a development methodology (e.g., waterfall, agile, ...) and the associated set of rules for developers	2 week	Do/Don't internal note
Development of an embryonic interface for early testing of the various modules	1 week	Embryonic command line interface
Implementation of the core Feynman diagram/matrix element generator	2 months	Working Feynman diagram/matrix element generator capable of reproducing results obtained with v4 (with the suitable test suite)
Interfacing with the existing MadEvent phase space integration method	2 months	The code passes an automatic numerical test suite for various processes available in v4.
Progressive implementation of the new physics features described in the research methodology or optimization of existing ones.	1 month cycles (less than 1 year in total)	For each cycle: implementation of a minimal but extensible test suite, and development until the code passes it. The test suite *defines* the code. Status report for each cycle. Possible short publication/ conference talk for each original method introduced.

Design and development of a new matrix element generator (less than 24 months)		
Subgoal	**Timescale**	**Assessment Criteria**
Development of an Alpha release only accessible to the team and a selected panel of advanced users	1 months	Alpha release passing simultaneously all test suites. New tests added from bug reports.
Development of a Beta release accessible to the community	2 months	Beta release with minimalist user manual and bug report system.
First stable release and publication of the software specification and early results obtained thanks to new features	2 months	Official stable release v5.0 and publication of the early physics results in a renowned journal.

Development of new methods for new physics signal searches at the LHC (2 x 12 months)		
Subgoal	**Timescale**	**Assessment Criteria**
Implementation of multipurpose evolutionary programming library in Python	2 months	Successful application to simple known problems (traveling salesman, ...)
Simulation of the automatic signal isolation of favorable new physics scenario (e.g., tri-muons) with low background using parton level MC data	2 months	Sufficient background rejection and stable behavior, possibility to give a physical explanation to the most discriminant variables.
Communication about the new method	3 months	Publication and talk(s) in international conferences.
Application of the method on less favorable scenarios using MC data with partial detector simulation and higher background rates	2 months	Same criteria as for parton level MC data + characterization of the behavior of the method with progressively larger backgrounds
Communication about the new method and, if successful, technology transfer to the experimental community	3 months	Talks in experimental groups, participation to the redaction of notes.

Development of new methods for new physics signal searches at the LHC (2 x 12 months)		
Subgoal	**Timescale**	**Assessment Criteria**
Application of evolutionary algorithm to the automatic generation of BSM “signatures”	3 months	New module for MadGraph v5
Test of the method with black boxes of parton level MC data	2 months	Amount of information extracted automatically about the signatures, assuming a model
Application of evolutionary algorithm to the automatic generation of BSM “scenarios”	3 months	New (external) module to generate MadGraph v5 models
Test of the method with black boxes of parton level MC data	2 months	Amount of information extracted automatically about the model
Communication of obtained results	2 months	Publication and/or talks in international conferences, in particular oriented towards applicability in a realistic experimental environment.

The timescales involved are simple estimates, and will be subject to change depending on problems encountered or alternative research directions that may present themselves in the course of the project. However, they are deemed to be reasonable estimates based on the previous experience of the applicant, his colleagues and the host institution. Many of the subgoals will only require a partial investment by the candidate himself (e.g., for new feature implementation where the applicant only has a supervising role), allowing them to be pursued simultaneously. Moreover, the two parts of the present proposal are structured independently and are expected to be worked out at in parallel. Thus, it is not the case that the mentioned timescales should add up to the total proposed duration of the project.

The tables above do not contain all of the criteria for assessment of the proposed project, which also aims at developing complementary skills. This part of the work-plan is summarized in the table below and will be pursued during for the whole duration of the proposal.

Complementary skills training	
Subgoal	**Assessment Criteria**
Preparation of conference talks, scientific papers, technical reports and manuals for developed computer softwares	Communication material and invitations to international meetings

Complementary skills training	
Subgoal	**Assessment Criteria**
Development of communication and management skills specifically oriented towards user support	Early and real time user support, continuous use of user feedback reports
Assistance in the training of students and early researchers	Students formal and informal feedbacks, quality of the communication materials produced by students

Practical and administrative arrangements and support for the hosting of the fellow

The researcher has been resident in Amsterdam (with his wife and newly born daughter) and working at the host institution for a number of months, thus all of the most immediate administration steps relating to residency and financial matters (accommodation, bank accounts) have already been undertaken. The applicant also attended a six month Dutch language course provided for foreign scientists, and already planned to attend more Dutch classes in the coming year.

The host institution has an active social society which aims at integrating researchers within the department and boosting staff morale by means of regular and well-attended events throughout the year. There is also a permanent personnel department within Nikhef, which advises foreign scientists on financial as well as more general matters concerning life in the Netherlands.

B5 IMPACT

Potential of acquiring competencies

There is ample scope within the proposed project for the acquisition of skills that should strongly enhance the applicant's prospects of reaching a position of professional maturity, diversity and independence. Regarding scientific skills, the required acquisition of new knowledge, especially in the field leading and next-to leading order QCD calculations, will clearly help the candidate to diversify his current profile and provide him with an excellent background for further career developments in the field of high energy physics phenomenology. This acquisition is very realistic in the context of the present proposal, especially by considering the scientific profiles of applicant, supervisor and host institution.

Concerning the more technical and/or complementary skills associated with the proposal, the further development of the applicant's project management skills will have obvious applications in possible future large-scale projects, whose subject may very well be suggested by this research. Once again, improvements of the fellow's skills in this direction are very probable, in particular due to the expected leadership position and the ambitious nature of the present proposal, which will require a careful planning of the available resources. Finally, communication abilities developed in the context of new collaborations, including inter-disciplinary ones, and assistance in the training of early researchers will also very positively impact the applicant's current skill portfolio, thus accelerating the transition towards independence and maturity.

Contribution to career development

In the medium term, the applicant will first benefit from an increased visibility in the high energy physics community thanks to its involvement at the highest level in the development of a promising application, with several cutting-edge new features. He will also highly benefit from close collaboration with experimental group(s), e.g., in the context of innovative analysis method development, at a crucial time for high energy physics in which phenomenology should, more than ever, be directed towards experimental goals. Finally, the skills and techniques acquired will be immediately useful in several other research projects relating to collider phenomenology, which will be an extremely fertile and active research area in the years immediately following the turn-on of the LHC, where there is a high potential for quality research of significant impact on the field of particle physics.

In the long term, the applicant will benefit immensely from the network of contacts set up for the achievement of the proposed projects. This network should provide an excellent base for further research and collaboration. If the MadGraph v5 application is actually used intensively and successfully in the quest for BSM physics at the LHC (for this it will be designed), the applicant will eventually also profit directly from this reputation thanks to his project leader position. Furthermore, there is an excellent scope for long-term personal development, thanks to the already mentioned various scientific and complementary skills to be built on in the context of the proposal.

Contribution to European excellence and European competitiveness

The proposed project has a very strong potential to positively impact the European excellence and competitiveness. It will lead to the development of innovative new tools which will possibly play a very important role for the discovery and characterization of new physics at the LHC, the world's leading particle accelerator for the coming years. Expertise amongst the theoretical community relating to Monte-Carlo simulations and experimental techniques can be expected to be sought after the new accelerator commences data taking, thus the topics and developments covered by this proposal cannot fail to make the host institution, and thus Europe in general, more attractive to prospective graduate students and more experienced researchers.

From a structural point of view, the proposed project will, thanks to its intrinsic collaborative nature, strengthen links at several levels. First, it will contribute to reaffirm or develop links between the host institution and other institutions in the context of the development MadGraph v5 project. Since the majority of the participants involved in this project originated from or are hosted in European countries, this will clearly benefit to the intra-European scientific community. Second, thanks to its cross-disciplinary nature, the proposal will help to consolidate existing links between the theoretical and experimental groups in the host institution by providing concrete subjects of collaboration. Given that the ATLAS experiment is worldwide, this will also initiate contact within a much wider setting.

Benefit of the mobility to the European Research Area

The applicant mobility will be beneficial to the European Research Area in a number of ways. First, by providing him with a suitable environment to lead and actively participate in the mentioned ambitious achievements, members from the European Research Area will be in a particularly good position to directly benefit from the associated results. Second, the fact the applicant will have the opportunity to directly interact intensively with several members of a renowned institution (theorists and experimentalists), guarantees much better personal development opportunities, especially regarding new scientific and complementary skills. Finally, the geographical decentralization of the researcher's activities with respect to other already well-established development centers (e.g., Louvain in Belgium for MadGraph v4) will help the candidate to reinforce his propensity to build on independent thinking, still allowing sufficient contact opportunities with external collaborators to ensure the credibility of the proposed ambitious project.

All these arguments also hold for the "genuine" researcher mobility aspect, which could be further developed by emphasizing significant differences between the applicant's previous work environment and the new one. I mention the national, purely research oriented dimension of the Nikhef institute, as opposed to the local, university based, working environment of the candidate during his PhD; or the involvement of the Nikhef institute in the ATLAS collaboration which has, beyond obvious similarities, several structural differences with the CMS collaboration in which Louvain is involved.

ENDPAGE

PEOPLE
MARIE CURIE ACTIONS

Intra-European Fellowships (IEF)
Call: FP7-PEOPLE-2009-IEF

PART B

“BSMTOOLS4LHC”