

Training and Transfer of Knowledge (ToK)

HEPTOOLS network undertakes to provide 340 person-months of ESR and 276 of ER whose appointment will be financed by the contract. Quantitative progress on this in conformance with relevant contractual provisions, will be regularly monitored at the consortium level.

As explained in the scientific programme, the multidisciplinary expertise of our network is, among other things, in creating and designing tools for the whole high-energy community, both the theoretical and the experimental one. Quantum Field Theory methods, highly sophisticated Monte Carlo generation and other symbolic programmes used by young researchers have already great use in other fields, ranging from advanced electronic technologies to highly competitive administrative and business services. The participation in the network of highly regarded groups of experts from USA, Japan and Russian Federation, will offer a *unique worldwide training environment*.

The structure of the network and the longstanding tradition of collaboration among its members will offer a unique opportunity for extending and consolidating a training and ToK programme aimed at integrating the various areas covered by the scientific programme.

(i) Training capability of the Network

Each node of the Network will operate, with different and complementary expertise, in achieving the specific tasks that are expected to be accomplished. The training and the research activity of young researchers will be deeply connected to these themes. There is a rapid evolution in the field which makes it hard to be very precise about the detailed tasks that will be performed in the longer run and we will define the longer-term milestones as 'progress' towards the broader goals of the proposal.

The training/ToK program addresses both the appointed ERs and ESRs. The project will help the researchers to realize common structures and connections between different fields of work.

Within the first two months of the appointment each young researcher will define with her/his supervisor her/his *Training Development Plan* which will be strictly related to the research activities of the node, including exchange of knowledge between different nodes; during her/his training the ESR will be assisted (whenever available) by ERs through a continuous interaction coordinated by the supervisor.

For all Contractors the ER Career Development Plan will be used to assess the implementation of the knowledge transfer aspects that the employment of this researcher is expected to facilitate. The members of our Network have a longstanding experience in providing training support to ESRs while our research goals offer suitable challenges for their scientific creativity.

In the following an outline of the expertise of the Contractors for Training/ToK programme (TTP) is provided. The list includes also the indicative topics the ESR and ER to be recruited by the corresponding Contractor (node), will be working on.

Nodes 1-4 6-13 15-17 will contribute in the TTP to the studies of multi-loop precision calculations and analytical/numerical methods to evaluate loop integrals, renormalization for precision calculations.

Nodes 1-4 6-8 10 12-17 will contribute in the TTP to the development of automated tools for arbitrary scattering processes with the introduction of novel methods for one-loop corrections to multi-particle amplitudes.

Nodes 1-2 4 6-8 10 12-17 will contribute in the TTP to the understanding of fully automatized Monte-Carlo generators with interfaces to parton-shower and hadronic generators, to the development of computer algebra packages for multi-loop calculations.

Nodes 1-4 7-10 12-13 15-17 will contribute in the TTP to the studies of precision calculations of strong and electroweak corrections at hadron colliders with extension to precision calculations for Linear-Collider physics.

Nodes 2-5 7 9 10 12 14-17 will contribute in the TTP to describe standard and non-standard interactions in the production and decays of top and bottom quarks including higher-order corrections to top production processes.

Nodes 1-7 9-17 will contribute in the TTP to Higgs-discovery processes, in particular development of methods to determine Higgs properties, Higgs in the MSSM and beyond.

Nodes 1-9 11-15 17 will contribute in the TTP to the better understanding of supersymmetric particle production and decays at hadron and lepton colliders, connecting LHC and ILC studies.

Nodes 2 4 5 7 9 10 12 14 will contribute in the TTP to the study of SUSY effects in rare decays and on determination of the CKM matrix.

Nodes 1-7 9 11-13 15 will contribute in the TTP to the investigation of phenomenologically relevant effects of higher dimensional theories and non-commutative space-time, CP-violation in the leptonic sector, neutrino physics

in Susy scenarios, bounds on the dark matter relic density.

Intense exchange of knowledge is expected between the Contractors listed in the same class of topics. A plan will be made for visits/secondments to other Contractors that the appointed ERSs/ERs will be expected to undertake.

(ii) Network-wide training and ToK activities

During the contract the main training and ToK activities related to the research objectives of the network and organized by its members will include schools:

- The *Graduate School in Physics at Colliders* in Torino. The school is tailored to the young researchers of the network, but we will continue our attempt to extend invitations to post-graduate students outside the network as well. We will organize a one day series of talks from the ERSs/ERs of the network aimed to increasing the level and the quality of ToK on our research activities.
- A *Graduate School for Particle Physics* financed by the Deutsche Forschungsgemeinschaft (DFG), and an *International Max Planck Research School on Elementary Particle Physics* financed by the Max Planck Society (MPG), has been installed recently at MPI Munich, Munich University, and Munich Technical University. Within that school, a regular Ph.D. course with a three-years programme is taking place. It will be possible for young researchers to be members and take advantage of the entire infrastructure.
- The school on *Computer Algebra and Particle Physics*, organized by DESY, Zeuthen, will provide education and training to students and young researchers at graduate and Ph.D. level on important aspects in the field of computer algebra, whose methods are used widely throughout elementary particle physics.
- The involvement of the CERN team will give young researchers the opportunity to attend courses within the *CERN Academic Training programme*.

Connected with our network there will also be a series of workshops, which the consortium will operate with a workshop dependent involvement:

- The *Zeuthen Workshop on Elementary Particle Theory, (Loops and Legs in Quantum Field Theory)* organized by the DESY node.
- The series of *International Conferences on Theoretical Physics*, organized by the Institute of Physics, University of Silesia (Katowice).
- The series of *ZuoZ Summer Schools on Particle Physics*, organized by the Paul Scherrer Institut.
- The international research workshop “*Calculations for modern and future colliders*” (CALC) which is held in the Joint Institute for Nuclear Research (Dubna) and sponsored by Heisenberg-Landau Programme and BMBF (Bundesministerium fuer Bildung und Forschung).
- HEPTOOLS members will also run the program *Advancing Collider Physics: from Twistors to Monte Carlos* in the Autumn 2007 (10 weeks).

The annual network meetings will coincide with one of these events within the corresponding year. The calendar will be fixed at the first network meeting.

At these meetings, the young researchers will be able to expose their most recent research results with a unique opportunity to start a direct collaboration with senior physicists of other nodes, and of the field in general. They will complement the foreseen visits to other participant groups.

(iii) Integration, tutoring and Career Development Plan (CDP)

We plan to considerably increase the number of graduate students in our network by recruiting in the first year of activity. As a general procedure:

- The success of the young researchers will be regularly monitored at the network level. Each young researcher will have a supervisor who will be one of the permanent staff in the node. The supervisor will be responsible for monitoring research progress and for matching training activities to the research milestones and deliverables (described in Sect. 1.1), distributed among the nodes of the network and to be assessed at the mid-term review. Within the first two months of the appointment each young researcher will define with her/his supervisor her/his *Career Development Plan* (CDP), fixing a calendar of visits and participation in the network activities above. In particular, each student should spend between 3 and 12 months out of the 36 usually required for finishing her/his Ph.D. in an institution different from the one where he/she is appointed. In this way he/she will benefit from being part of a unique project where several experts will be able to cover a much broader spectrum in the training programme under the network coordination. Besides, all young researchers will be invited to attend the annual network meetings, where most of the time will be allocated to them to present their work and to plan further activities. These events will provide the natural environment for a closer interaction with all members of our network, thus providing a very good training ground for post-graduate students and young researchers.
- Each node will have regular discussions concerning the progress of the group's research at which any problem with the appointees will be highlighted by the supervisor concerned. The training committee will ensure the proper implementation of the many facets of the project and in close contact with the representatives of all the partners will determine the most opportune way of proceeding. An additional control over the training - milestones matching is to be found in the presentations of the young researchers work at schools, workshops, etc; these informations will be stored in the network database.
- We will consider the good balance of gender a major commitment and the network. We will use the network potential to stimulate the motivations of more and more young female researchers for this area.

The network will optimize the chances of young researchers of continuing a career in the field, and will assist them in practical matters through the channels already used for their recruitment outside the network.

(iv) Training and mobility programme

Each single team in the network is an *institute for advanced research at the doctoral level* and organizes courses leading to a doctoral degree. Each team also has a long experience of training. There are many long and useful collaborations among the teams with a few examples of bilateral agreements, e.g. NCSR-Demokritos, Nijmegen, Durham, Torino and Freiburg who have signed conventions, and will organise doctoral programmes in agreement with the local, regional, national and international authorities.

In order to be able to achieve the optimal ratio between individual training, as offered by single teams where the students will spend the largest fraction of their time, and network-wide training. The network besides intends to train the researchers as follows.

- We are able to provide high-quality individual training and transfer of knowledge through courses and tutorials where all teams will benefit. We will concentrate in one place and for a short period (from few weeks to a month) a larger group of ESR and ER, to interact with world-leading specialists while following specific courses. We are also planning shorter and, sometimes, more specialized training activities by gathering groups of graduate-students in one of the nodes. There they will be able to follow courses and tutorials, to be fully recognized by their home institutions, that would be otherwise missing in their educational record. The whole program will be naturally extended to all graduate-students of the network, independently from being financed by the network itself.
- We will try to go beyond short-term mobility since our students will have to Europeanise their curriculum, we will sustain mobility of teachers (apart from short stays) and training and integration in a truly European perspective. We aim to offer an internationally renowned, attractive research environment with complementary training modules developing the additional necessary skills for highly qualified young scientists.

(v) ToK programme

We plan to have a comprehensive program which will collect applications from all the nodes and will constantly monitor the progress in research activities connected to exchange of young researchers. The outcome of such

project will be verified during our annual meetings with oral presentations and with written documentation. Young researchers will be encouraged to present their results and the results of the network at international conferences and workshops, based on a carefully designed yearly schedule.

We also plan to have an efficient web site where all the activities and opportunities in the network will be fully documented and will appear as soon as they are predictable in time. Within the meetings the young people will be informed about the overall status and the outcomes of the project.

Schools organized by the network will help us in the project; lectures at the schools will be video-recorded to create a useful library for the training programme.

In order to achieve a better coordination of the local and network-wide training and transfer of knowledge activities, a synergy with projects currently financed by Marie Curie Transfer of Knowledge and Marie Curie Excellence Grants programmes, involving several teams of the proposed network, will be planned, making optimal use of the existing resources.

(vi) Complementary and instrumental skills

As an important point, our project will sustain our constant attempt to keep excellent young researchers in European institutions. Transfer of knowledge to new generations is essential to maintain Europe's leadership and to facilitate further progress in the field.

A collateral benefit of this commitment is the training of recruited researchers in complementary fields, especially from their interaction with experimentalists. The involvement of the CERN team is essential since it will guarantee an optimal coordination for short and medium visits of young researchers giving them the opportunity for a close contact with experimental colleagues working for LHC. Furthermore, most of the nodes are institutions with a large component of senior researchers in different branches of experimental physics ranging from low to high energy particle physics and including neutrino and astroparticle physics. A daily interaction represents the ideal way to stimulate complementary training (joint lectures, seminars, etc). Through the interaction with experimental senior researchers we will exploit the complementary expertise of institutions outside the network, noticeably industry, with ad hoc knowledge transfer schemes.

The young researchers of our network will therefore participate in long-term projects connected with the interdisciplinary aspects of present and future generation of large colliders. They will learn how to formulate problems and how to search for a solution which can be immediately used by other members of the European and international community to continue digging into the most relevant aspects of collider physics.

The range of the network research extends from mathematical to particle physics and software problems. The multidisciplinary training of young researchers is thus naturally guaranteed. The Quantum Field Theory methods, sophisticated Monte Carlo generation and other symbolic programmes used by the young researchers have great use in other fields, ranging from advanced electronic technologies to highly competitive administrative and business services.