



Training Activity

CONTRACT NO. 35482

Report for the period 01/10/2007 — 30/09/2008

We present here the report on Training and TOK activities of the *Marie Curie Research and Training Network FLAVIANet*. The Training and TOK activities have been organized, supervised and coordinated among the several nodes by the FLAVIANet Training Committee composed by M. Davier (Orsay), S. Descotes Genon (Orsay), P. Krizan (Ljubljana), P. Hernandez (Valencia), T. Mannel (Siegen), C. T. Sachrajda (Southampton) and chaired by N. Brambilla (U. Milano).

In the following we report the training and TOK achievements for each of the eleven FLAVIANet nodes in the period 01/10/2007–30/09/2008 indicated in the following as *YEAR 2*.

As it is reported here, at this time the training program of the network has been successfully started and is being intensively developed at all nodes and in all the network.

For each one of the Early Stage Researchers (ESR) and each one of the Experienced Researchers (ER) a detailed and personalized Career Development Plan has been constructed by the Network Training Committee in collaboration with the node tutors. In establishing the Career Path for our researchers we have considered a global Career Plan covering both short term and long terms objectives, being the long term ones projected over a period of five years, thus including also the time after the conclusion of this network. The network has been fully committed to grant to the young researcher all the relevant skills and tools to allow them to develop into independent and creative researchers, to enlarge and create their own scientific vision, to make possible that they acquire all the relevant scientific, managerial, leadership and communicational capabilities such to open up different perspectives and opportunities for them in the future. As it is explained in the report this basic aim is being pursued with a diversified, smart and innovative set of training measures, training relationships and training situations.

As it is detailed in the several sections of the report, for each node the training and transfer of knowledge program is being articulated at the following levels:

- *Individual training*
- *Intra-Node Training*
- *Inter-Node Training*
- *Network Training.*

The General Training Measures have been organized in: the Annual General Meeting held in Orsay in November 2007 (detailed in the FLAVIANet Research Report), the Annual European Flavour Physics Schools of 2008 and several Research Training Workshops (detailed in the FLAVIANet Research Report).

The Annual European Flavour Physics School of 2008 has been organized at the Benasque Physics Center, Spain, as the “International Flavor School” from 13th to 25th of July, 2008. The School has been devoted to the theoretical and experimental developments in Flavour physics

and Effective Field Theories and lectures have been given by world experts in the subject coming from the network and from outside the network (USA, Canada, Japan). The main lectures have been:

- E. Braaten (Ohio U.): Introduction to Effective Field Theories
- M. Neubert (Mainz U.): Flavor Physics Phenomenology
- T. Nakada (EPFL): Flavor Physics Experiments
- M. Lüscher (CERN): Introduction to lattice QCD
- H. Leutwyler (Bern): Chiral Perturbation Theory
- A. Pineda (Barcelona): Nonrelativistic QCD
- A. Vairo (Milano): Nonrelativistic QCD at Finite T
- I. Stewart (MIT): Soft Collinear EFT
- B. Kubis (Bonn): Baryon Chiral Perturbation Theory
- M. Laine (Bielefeld): QCD at Finite Temperature and chemical potential
- D. d'Enterria (CERN): High Energy Experiments
- C. Burgess (Perimeter Institute): Physics Beyond the Standard Model
- S. Frixione (CERN): Introduction to perturbative QCD and LHC Physics

A total of about 70 students from all over the world have attended the school with about 40 students (Ph.D. and post-doc) coming from the FLAVIANet nodes.

Tutorials with exercises assigned by the lecturers have been organized in the afternoons. The exercises have been solved by the Early Stage Researchers with the assistance of young Tutors chosen among the Postdocs of the network. Such activity has resulted to be very intense, very well participated by ESR and ER researchers and of very high and multiple training impact. All the skills, from the technical and scientific capabilities to the communication and teaching skills and the leadership and organizational talents, have been developed in a nice and natural way through this activity.

Inside the FLAVIANet the young researchers have access to a lively, cutting-edge scientific frame and to countless and concrete opportunities to interact with the best European and International experts in Flavour Physics. Besides this, we take the appropriate care to train our researchers in several complementary skills, including a training in experiments and in intensive computational methods. Particular attention has been given to the training in communication and presentation skills, vital for a scientist, and to the interdisciplinary aspects of the research.

The Early Stage Researchers and the Experienced Researchers have been appointed through an open and transparent procedure following the publication of the openings on the European web servers and on several job webpages. The recruitment procedure and the subsequent arrival in the node of the selected researchers have been closely monitored by the Training Committee. As it has been mentioned at the beginning for each ESR and ER a personal and individualized Career Plan has been established and realized. This is detailed in the Section "*Career Development Plan, Tutoring, Advising, Opportunities*" for any ESR and ER hired at any node. The already rich environment of the FLAVIANet nodes has been complemented with lectures, courses and seminars given by experts coming from outside the node, secondments of ESR, ER and FLAVIANet experts among the nodes as well as complimentary skills and language courses.

The recruitment process of ESR and ER has proceeded as planned. By this reporting period, we

have already appointed a total of 25 young researchers (4 ER and 21 ESR) for a total of 461 months (84 ER months and 377 ESR months). 17 of those contracts (3 ER and 14 ESR) with a total of 322 person-months (60 ER months and 262 ESR months) have already been started. This together with the Ph. D. and postdoc positions existing inside the FLAVIANet nodes and funded by other sources constitutes the biggest cluster of young researchers in Flavor Physics inside Europe and perhaps in the world.

1 Training and TOK achievements

1.1 Node No. 1: Spain-V (Universitat de València Estudi General [UVEG])

YEAR 2

1.1.1 OFFERED PH. COURSES (LOCALLY)

The Valencia node offers a complete programme of Ph.D. courses in theoretical and experimental particle and nuclear physics. The most relevant ones for the FLAVIANet topics are :

- Ph.D. Course on “Quantum Chromodynamics”, Valencia, November 2007 - May 2008.
- Ph.D. Course on “Non-perturbative methods”, Valencia, January - May 2008.
- Ph.D. Course on “Theory and Phenomenology of the Strong Interactions”, Valencia, November 2007 - May 2008.
- Ph.D. Course on “Electroweak interactions”, Valencia, November 2007 - May 2008.
- Ph.D. Course on “Advanced Quantum Field Theory”, Valencia, October 2007- January 2008.
- Ph.D. Course on “Experimental Nuclear Physics”, Valencia, October 2007 - January 2008.
- Ph.D. Course on “High Energy Physics”, Valencia, January - May 2008.
- Ph.D. Course on “Advanced Phenomenology”, Valencia, January - May 2008.

1.1.2 OFFERED COURSES at ANY LEVEL of interest for the FLAVIANET

- Undergraduate Course on “Quantum Field Theory”, Valencia, September 2007–May 2008.
- Postgraduate Course on “Neutrino Physics”, given by P. Hernández at the 2008 European School of High-Energy Physics, Herbeumont-sur-Semois, Belgium, 8 June - 21 June 2008.

1.1.3 COURSES/TRAINING ACTIVITIES BY MEMBERS OF THE NETWORK in DIFFERENT NODES/SUBNODES

- Course on “The Standard Model”, given by A. Pich (node 1) at CERN (node 9), July 2008.
- 1 Ph.D. student (Pablo Roig, node 1) has participated in the “V International Workshop on Heavy Quarkonium 2007”, at DESY, Hamburg, Germany (node 11), 17th - 20th October 2007.
- 1 Ph. D. student (Pablo Roig, node 1) has participated in the “EuroFlavour ’07”, FLAVIANet meeting at Univ. Paris-Sud 11, Orsay, France (node 8), 14th-16th November 2007. One talk was presented : “Hadronic tau decays into two kaons and a pion within Resonance Chiral Theory”.
- 1 Ph. D. student (Pablo Roig, node 1) has participated in the “LIII Rencontres de Moriond”, in the session devoted to QCD and High-Energy interactions, La Thuile, Aosta, Italy (node 5), 8th - 15th March 2008. One talk was presented : “Hadronic structure of the decays $\tau \rightarrow K \bar{K} \pi \nu_\tau$ ”.
- 1 Ph. D. student (Pablo Roig, node 1) has participated in the “PhiPsi08: International Workshop on e^+e^- collisions from Φ to Ψ ”, Laboratory Nazionali di Frascati, Italia (node 5), 7th - 10th April 2008. One talk was presented: “A proposal for improving the hadronization of QCD currents in TAUOLA”.
- 1 Ph. D. student (Pablo Roig, node 1) has participated in the “III Meeting of the Working Group on Radiative Corrections and MC Generators for Low Energies” (with participation of the FLAVIANet Working Group on Radiative Return and Monte Carlo tools), Laboratori Nazionali di Frascati, Italia (node 5), 11th April 2008. One talk was presented: “A proposal for improving the hadronization of QCD currents in TAUOLA”.
- 2 Ph. D. students (Pablo Roig, Martín González-Alonso, node 1) have participated in the “QCD08”, 14th International QCD Conference, Montpellier, France (node 8), 7th-12th July 2008. Two talks were presented :
 - P. Roig, “Improving the hadronization of QCD currents in TAUOLA”.
 - M. González-Alonso, “Determination of chiral low-energy constants from tau data”.
- 5 Ph. D. students (Pablo Roig, Martín González-Alonso, Paula Tuzón, Alberto Filipuzzi, Fabio Bernardoni, node 1) have participated in the “School of Flavor Physics”, Benasque, Spain (node 2). School organized by the FLAVIANet network, 13th-25th July 2008.
- Training stay of the Ph.D. student Pablo Roig at Institut für Physik, Johannes Gutenberg Universität, Mainz, Germany (node 11), from October 13th 2007 until December 16th 2007.
- Training stay of the Ph.D. student Vicent Mateu at MPI, Munich, Germany (node 4), from September 16th 2007 until December 2nd 2007.

1.1.4 VISIT of SENIOR SCIENTISTS from OUTSIDE the NETWORK

- Belén Gavela (IFT Madrid, Spain), 4-5 October 2007
- Ann Nelson (University of Washington, Seattle, USA), 21-23 November 2007
- Oscar Catá (Lawrence Berkeley National Laboratory, USA), 3-5 December 2007
- Abe Seiden (Santa Cruz Institute for Particle Physics), 10-14 December 2007
- Roberto Ruiz de Austri (IFT Madrid, Spain), 29-30 January 2008
- David Kaplan (INT, University of Washington, Seattle, USA), 22-25 April 2008

1.1.5 ORGANIZED SCHOOLS

- School on Flavour Physics, Benasque (Spain), 13th-25th July 2008.

Flavianet ESR participating: Vicent Mateu (node 4), Miguel Angel Escobedo, Javier Virto (node 5), Ilaria Jemos (node 7), Nils Offen (node 8), Michael Donnellan, Francesco Virota (node 11)

Flavianet ER participating: Artyom Hovhannisyán (node 4)

Flavianet Members participating:(names)

Pablo Roig, Martín González-Alonso, Paula Tuzón, Alberto Filipuzzi, Fabio Bernardoni (node 1).

Diego Boito, Miguel Angel Escobedo, Clara Estela Jiménez, Pere Masjuan, Jorge Mondéjar, Antonio Pineda, Juan J. Sanz-Cillero, Marc Ramón, Joan Soto, Jaume Tarrús (node 2).

Aoife Bharucha, Javier Cobos-Martínez, Eike Mueller, Hugo Pedroso de Lima, David Wilson (node 3).

Guido Bell, Andreas Crivellin, Lars Hofer, Artyom Hovhannisyán, Vicent Mateu, Christoph Reisser, Sascha Turczyk, Leonardo Vernazza (node 4).

Nora Brambilla, Jacobo Ghiglieri, Antonio Vairo, Javier Virto, (node 5).

Ilaria Jemos (node 7).

Nils Offen (node 8).

Stefano Frixione, Heiri Leutwyler, Martin Lüscher, Vidushi Maillart, Tatsuya Nakada, Martin Schmid, Alessio Vaghi, Christoph Weiermann (node 9).

Nejc Košnik (node 10).

Michael Donnellan, Xu Feng, Jenifer González-López, Dirk Hesse, Jim Kallarackal, Bastian Kubis, Mikko Laine, Francesco Virota (node 11).

1.1.6 GENERAL TRAINING

- General IFIC Seminar, weekly from September to July
- IFIC Colloquium, monthly from September to July
- Specialized IFIC seminars, weekly from September to July
- Undergraduate Physics Seminar, Univ. Valencia, monthly from November to May
- Theory Seminars, Physics Faculty of Groningen University, weekly from September to July
- Physics Colloquium, Physics Faculty of Groningen University, weekly from September to July

1.1.7 ER HIRED (October 1, 2007 – September 30, 2008)

- David Greynat, hired in Valencia on 24 September 2007, ER one year contract.

1.1.8 ER PERSONAL CAREER DEVELOPMENT PLAN TUTORING, ADVISING, OPPORTUNITIES

- **David Greynat, ER contract, Valencia**

David Greynat has started his ER contract (12 months) on 24 September 2007. His local advisor is Antonio Pich. He receives local guidance from several members of the Valencia group (Jorge Portolés, Pilar Hernández, Roberto Bonciani) and from members of other FLAVIA*net* nodes (Eduardo de Rafael, Marseille). Complementary training on experimental physics is offered locally by Fernando Martínez.

Brief overview of research project and major accomplishments expected

The research work of David Greynat concerns the analytical study of multi-scale Feynman graph topologies, in order to obtain some higher-order corrections to the muon magnetic anomaly and K_{l3} form factors in explicit analytical form.

David has developed a very elegant procedure to calculate asymptotic expansions of Feynman diagrams. This new method is based on a clever use of the Mellin transform to separate the dependences on the Feynman parameters from the mass scales. In this way, one can obtain expansions at low or large values of a given mass scale, without having an explicit analytical formula for the corresponding Feynman amplitude. Through the study of a few physical applications he has demonstrated the big advantage of the Mellin transform in comparison with the computational strategies adopted in previous works.

In Valencia David has integrated in a joint effort to get analytical expressions for the K_{l3} form factors at the two-loop level in ChPT. This is a highly non-trivial task, since only numerical results exist so far. The present discrepancies between Chiral Perturbation Theory

results and lattice simulations make necessary to achieve a better understanding of the two-loop corrections through analytical formulae. These results are relevant for the accurate determination of V_{us} . Using his Mellin techniques, David is computing the needed Master integrals, with three different mass scales.

In parallel, and in collaboration with the CNRS node (Marseille), David Greynat has been developing new techniques to compute higher-order corrections to the electron and muon anomalous magnetic moment in analytical form. Using the Mellin transform techniques, it is possible to calculate the lepton QED vacuum polarization contributions at eighth and tenth orders. Some contributions had been already computed analytically by Laporta, but this technique allows to reproduce them in a much simpler way. Some others had been estimated numerically by Nio and Kinoshita, and agree remarkably well with the new analytic results obtained by David and his collaborators. What is more important, they have been able to provide for the first time the results of those contributions involving three mass scales: m_e , m_μ and m_τ ; this is a rather remarkable achievement.

Long-term career objectives (over 5 years)

David Greynat got his Ph. D. at Marseille (node 8), under the supervision of Eduardo de Rafael. His Ph. D. research was focused to the study of three different problems, which have in common the presence of strong interactions in the non-perturbative regime: rare K decays, chiral condensates and the application of the Mellin transform to compute the muon anomalous magnetic moment.

FLAVIANet offers the possibility to interact with experts on all these fields and broaden his personal expertise. The main goal of his ER stay at Valencia has been the implementation of Mellin transform techniques in ChPT calculations at the two-loop level. In addition to the usual quantum field theory framework, the required technical expertise include sophisticated mathematical tools, such as multi-variable complex analysis, special functions and Hilbert (and other) transformations. David has profit from the simultaneous presence at IFIC of higher-loop practitioners and a consolidated group with long-term expertise in ChPT techniques. In addition, he has been in contact with local mathematicians to broaden his knowledge on these techniques.

The mathematical expertise of David Greynat has proved to be very useful for the training of the local PhD students of the Valencia node, which can profit from his very professional advise.

At the end of September 2008, once his present ESR contract at Valencia will be finished, David Greynat will move to IFAE in Barcelona (node 2), where he will continue his postdoctoral training with a two-year contract funded by IFAE. He will continue working within Flavianet, so that his present expertise can be used to attain the Flavianet scientific goals.

Short-term objectives

David has already obtained very relevant results, which will be made public soon. He has

recently published in The Physical Review D a new article on the muon $g - 2$, written in collaboration with E. de Rafael and J.-P. Aguilar (arXiv:0802.2618 [hep-ph]), with very important achievements. Additional results on $g - 2$ and the K_{l3} form factors are expected in a few months.

The FLAVIANet general meetings constitute an ideal environment to discuss the new results, getting feed-back from the scientific community and improving at the same time the communication skills of the ER/ESR fellows. David already presented part of his results at the past EuroFlavour07 Conference in Paris. The new achievements he has made since then, will be presented at the next EuroFlavour08 Conference in Durham.

1.2 Node No. 2: Spain-B (Univ. Autonoma de Barcelona, Univ. de Barcelona, Univ. Politecnica de Catalunya, Univ. de Granada and Univ. de Huelva)

YEAR 2

1.2.1 OFFERED PH.D. COURSES (LOCALLY)

The Ph.D. courses at the different universities comprised in this node have followed the same structure as the previous year.

Examples of courses taught are:

- "The Standard Model: A Reminder", taught by R. Escribano within the Master "Advanced and Professional Physics" at UAB.
- "Advanced Quantum Field Theory", taught by M. Jamin within the Master "Advanced and Professional Physics" at UAB.
- "The Standard Model and its Phenomenology", taught by F. Cornet and J. Prades within the Master "Advanced Methods and Techniques in Physics (MTAF)" at UG.

More details and the syllabuses may be found at the different webpages for the corresponding masters:

- Master at UB: <http://www.am.ub.es/master-AFPC/index-eng.html>
- Master at Granada: <http://www.ugr.es/mtaf/Informacion-EN.htm>
- Master at UAB: <http://bioinf3.uab.cat/masterfisica/>

1.2.2 OFFERED COURSES at ANY LEVEL of interest for the FLAVIANET

- School on Flavor Physics, organized by J. Soto, Centro de Ciencias de Benasque "Pedro Pascual", July 2008. Webpage with further details: <http://benasque.ecm.ub.es/2008flavor/2008flavor.htm>

1.2.3 ESR HIRED

- Cailin Farrell, who started at UB on May, 2008.

1.2.4 ESR PERSONAL CAREER DEVELOPMENT PLAN TUTORING, ADVISING, OPPORTUNITIES

- Name of the Fellow: Cailin Farrell
- Workplace: Universitat de Barcelona, Dept. d'Estructura i Constituents de la Materia, Barcelona (Spain).
- Name of Supervisor: Prof. Joan Soto

Brief overview of project and major accomplishments expected

In the regime where quarks become nonrelativistic, usual perturbation theory breaks down and cannot be applied to describe the nonrelativistic dynamics. For the accurate description of many Standard Model parameters, such as the quark masses and couplings, or CP violation, it is however necessary to have a precise description of these nonrelativistic dynamics. Therefore, one uses effective theories which are more adapted to the system; for heavy quarks, these are called Nonrelativistic QCD (NRQCD). In the first stage of the project the effective theory methods of velocity NRQCD (vNRQCD) will be applied to the problem of extracting the top Yukawa coupling at a future International Linear Collider (ILC) at next-to-leading logarithmic order. Then the fellow will apply her expertise to other systems including heavy quarks and other high-energy experiments, in particular using the effective theory potential NRQCD (pNRQCD).

Long-term career objectives (over 5 years)

During her PhD the fellow studied the production of Higgs bosons in association with top-antitop-quark pairs at the future International Linear collider in the regime in which the top-quark pair is nonrelativistic. The determination of this cross section allows for a precise determination of the top Yukawa coupling. The long-term goal is to pursue this line of research, as well as extending her expertise to systems with other heavy quarks and at other high-energy colliders. To attain this goal it is necessary that the fellow collaborates with experts in those fields and attends conferences and workshops related to the topics of her interest.

Short-term objectives (1-2 years)

- Anticipated publications: The fellow plans to publish two papers per year.

Anticipated conference, workshop attendance, courses and/or seminar presentations: Flavianet conferences, seminar talks at the internal seminars, seminar talks at other universities, and other conferences and workshops concerned with flavour physics, effective theories and collider physics.

- Research Management: No management duties.

Fellowship or other funding applications planned: No other funding is planned.

- Communication skills: The communications skills will be improved through talks within the UB as well as at other institutions.

- Other professional training (course work, teaching activity): The fellow attends the seminars at the UB on a range of subjects within physics.

- Anticipated networking opportunities: The fellow will participate at the yearly Euroflavour network meetings, the next of which will take place in Durham in September 2008. In addition, the fellow will extend her network through collaborations with other scientists in the network.

- Other activities (community etc) with professional relevance: The fellow is learning Spanish.

1.3 Node No. 3: United Kingdom

YEAR 2

1.3.1 OFFERED PH.D. COURSES (LOCALLY)

The UK node offers a complete programme of Ph.D. courses in theoretical and experimental particle physics relevant to *FLAVIANet*. Those offered in Durham and Southampton are:

- Ph.D Course on “Overview of Particle Physics”, Durham, October-May 07/08
- Ph.D Course on “Introductory Field Theory”, Durham, October-May 07/08
- Ph.D Course on “Group Theory”, Durham, October-May 07/08
- Ph.D Course on “Symmetries”, Southampton, October-May 07/08
- Ph.D Course on “Standard Model”, Durham, October-May 07/08
- Ph.D Course on “Standard Model”, Southampton, October-May 07/08
- Ph.D Course on “General Relativity”, Durham, October-May 07/08
- Ph.D Course on “Quantum Electrodynamics”, Durham, October-May 07/08
- Ph.D Course on “Quantum Field Theory”, Durham, October-May 07/08
- Ph.D Course on “Quantum Field Theory”, Southampton, October-May 07/08
- Ph.D Course on “Conformal Field Theory”, Durham, October-May 07/08
- Ph.D Course on “Conformal Field Theory”, Southampton, October-May 07/08
- Ph.D Course on “Lattice Field Theory”, Southampton, October-May 07/08
- Ph.D Course on “Supersymmetry”, Durham, October-May 07/08

- Ph.D Course on “Supersymmetry”, Southampton, October-May 07/08
- Ph.D Course on “Anomalies”, Durham, October-May 07/08
- Ph.D Course on “Strong Interaction Physics”, Durham, October-May 07/08
- Ph.D Course on “Cosmology”, Durham, October-May 07/08
- Ph.D Course on “Cosmology”, Southampton, October-May 07/08
- Ph.D Course on “Superstrings and D-Branes”, Durham, October-May 07/08
- Ph.D Course on “Strings and Brane Theory”, Southampton, October-May 07/08
- Ph.D Course on “Non-perturbative Physics”, Durham, October-May 07/08
- Ph.D Course on “Euclidean Field Theory”, Durham, October-May 07/08
- Ph.D Course on “Effective Field Theory”, Durham, October-May 07/08
- Ph.D Course on “Particle Phenomenology”, Southampton, October-May 07/08
- Ph.D Course on “Flavour Physics and Neutrinos”, Durham, October-May 07/08
- Ph.D Course on “Integrability in Quantum Theory”, Durham, October-May 07/08
- Ph.D Course on “Introduction to AdS/CFT”, Durham, October-May 07/08
- Ph.D Course on “Extra dimensions in gravity”, Durham, October-May 07/08
- Ph.D Course on “Computing for Physicists”, Durham, October-May 07/08
- Ph.D Course on “MHV-rules, recursion relations and unitarity”, Durham, October-May 07/08
- Ph.D Course on “Experimental techniques”, Durham, October-May 07/08
- Ph.D Course on “Simulations in high energy physics”, Durham, October-May 07/08

Similar courses are offered in Oxford. All first year postgraduate students similarly receive on 2 - 3 hours lectures per day for 24 weeks covering the whole range of particle theory and phenomenology. This is itself a matter of choice (whether to take certain courses in the Mathematics Department or in Physics in addition to core courses on field theory, electroweak, QCD both perturbative and non-perturbative and lattice QCD as listed above).

1.3.2 COURSES/TRAINING ACTIVITIES BY MEMBERS OF THE NETWORK in DIFFERENT NODES/SUBNODES

- A. Bharucha (PhD student, Durham) made a research visit to the Technical University Munich 8-15 June, 2008.
- A. Bharucha (PhD student, Durham) participated in *FlaviaNet summer school on Flavour Physics*, Centro de Ciencias de Benasque “Pedro Pascual”, Benasque, Spain, 13-25 July 2008.
- J.J. Cobos-Martinez (PhD student, Durham) participated in *FlaviaNet summer school on Flavour Physics*, Centro de Ciencias de Benasque “Pedro Pascual”, Benasque, Spain, 13-25 July 2008.
- D.J. Wilson (PhD student, Durham) participated in *FlaviaNet summer school on Flavour Physics*, Centro de Ciencias de Benasque “Pedro Pascual”, Benasque, Spain, 13-25 July 2008.
- C. Albertus (Post Doc., Southampton) participated in *HackLatt 2008, workshop for lattice QCD scientists*, Edinburgh, 1-3 April 2008.
- D. Brömmel (Post Doc, Southampton) participated in *HackLatt 2008, workshop for lattice QCD scientists*, Edinburgh, 1-3 April 2008.
- D. Brömmel (Post Doc., Southampton) participated in the *XXVI International Symposium on Lattice Field Theory*, Williamsburg, 14-19 July 2008.
- D. Brömmel (Post Doc., Southampton) participated in the *Annual Theory Meeting*, Durham, 17-19 December 2007.
- M. Donnellan (PhD student, Southampton) participated in *HackLatt 2008, workshop for lattice QCD scientists*, Edinburgh, 1-3 April 2008.
- M. Donnellan (PhD student, Southampton) participated in *FlaviaNet summer school on Flavour Physics*, Centro de Ciencias de Benasque “Pedro Pascual”, Benasque, Spain, July 13-25 2008.
- H. Pedroso de Lima (PhD student, Southampton) participated in *HackLatt 2008, workshop for lattice QCD scientists*, Edinburgh, 1-3 April 2008.
- H. Pedroso de Lima (PhD student, Southampton) participated in *FlaviaNet summer school on Flavour Physics*, Centro de Ciencias de Benasque “Pedro Pascual”, Benasque, Spain, July 13-25 2008.

1.3.3 GENERAL TRAINING

- Theoretical particle physics seminars in Durham, Oxford and Southampton, several times per week. Postdoctoral researchers and PhD students are expected to give at least one talk each year. In addition, there are lunch-time seminar groupings in particle phenomenology in each of the 3 institutions.
- Colloquia in Durham, Oxford and Southampton, several times per month.

1.4 Node No. 4: Germany–South (Universität Karlsruhe (TH))

YEAR 2

1.4.1 OFFERED PH. COURSES (LOCALLY)

- Course: *Quantum Field Theory II*, Aachen, Apr — Jul 2008
- Block course *Monte Carlo generators* given by Peter Skands, Aachen, Nov 2007
- Block course *Supersymmetry: Base and LHC projection* given by Peter Zerwas, Aachen, Jan 2008
- Student Seminar: *Key Experiments in Particle Physics*, Karlsruhe, Apr – Jul 2008
- Student Seminar: *Physics at KLOE and BaBar*, Karlsruhe, Apr 2007 - Feb 2008
- Course: *Advanced Particle Physics*, Karlsruhe, Oct 2007 - Feb 2008
- Course: *Nuclear and Particle Physics*, Mainz, Apr 2008 - July 2008
- Student seminar: *The Big Bang and its particles*, Karlsruhe, Oct 2007 - Feb 2008
- Student seminar: *Collider physics*, Karlsruhe, Oct 2007 - Feb 2008
- Student seminar: *Physics beyond the Standard Model*, Karlsruhe, Oct 2007 - Feb 2008
- Course: *Advanced Particle Physics*, Karlsruhe, Oct 2007 - Feb 2008
- Course: *Theoretical Particle Physics*, Karlsruhe, Oct 2007 - Feb 2008 and May–Jul 2008
- Course: *Physics beyond the Standard Model*, Karlsruhe, Oct 2007 - Feb 2008 and May–Jul 2008
- Advanced seminar: *B physics lunch*, Karlsruhe, Oct 2007 - Feb 2008
- Advanced seminar: *Flavour and Supersymmetry*, Karlsruhe, Oct 2007 - Feb 2008
- *Physik mit Höchstenergetischen Teilchenbeschleunigern*, Munich, May–Jul 2008

- *Quantenfeldtheorie*, Munich, May–Jul 2008
- *Theoretische Elementarteilchenphysik I&II*, Munich, Oct 2007 – Feb 2008 and May–Jul 2008
- *Cosmic Nucleosynthesis*, Munich, Oct 2007 – Feb 2008
- *Nuclear Astrophysics*, Munich, May–Jul 2008
- *Physik am Large Hadron Collider*, Munich, Oct 2007 – Feb 2008 and May–Jul 2008
- *Introduction to Flavour Physics*, Siegen, Oct 2007 – Feb 2008
- *Applications of QCD*, Siegen, Jul. 2008
- *Effective Field Theories*, Siegen, Jun. 2008
- *Models with extra dimensions*, Siegen, Apr. – Jul. 2008

1.4.2 OFFERED COURSES at ANY LEVEL of interest for the FLAVIANET

- *Kern- und Teilchenphysik I& II*, Munich, Oct 2007 – Feb 2008 and May–Jul 2008
- *Introduction to Nuclear & Particle Physics I&II*, Munich, Oct 2007 – Feb 2008 and May–Jul 2008
- *Tests des Standardmodells der Teilchenphysik I&II*, Munich, Oct 2007 – Feb 2008 and May–Jul 2008
- *Supersymmetrie an Collidern und in der Kosmologie*, Munich, Oct 2007 – Feb 2008
- *Repetitorium der Kern- und Teilchenphysik*, Munich, Oct 2007 – Feb 2008
- *Einführung in die QCD*, Munich, Oct 2007 – Feb 2008
- *Astroteilchenphysik I&II*, Munich, Oct 2007 – Feb 2008 and May–Jul 2008
- *Einführung in die Astrophysik I& II*, Munich, Oct 2007 – Feb 2008 and May–Jul 2008
- *Computational Astrophysics*, Munich, Oct 2007 – Feb 2008
- *Happy Hour der Kern- und Teilchenphysik*, Munich, Oct 2007 – Feb 2008 and May–Jul 2008
- *Experimentelle Methoden der Astroteilchenphysik*, Munich, Oct 2007 – Feb 2008
- *Standard model of particle physics*, Siegen, Oct 2007 – Feb 2008
- *Quantum Chromo Dynamics*, Siegen, Apr. – Jul. 2008

1.4.3 VISIT of SENIOR SCIENTISTS from OUTSIDE the NETWORK

- Dr. Andrey Grozin, *BINP* Novosibirsk, Russia, to Univ. Karlsruhe, Mar–May 2008
- Dr. Peter Lukin, *BINP* Novosibirsk, Russia, to Univ. Karlsruhe from Sep–Nov 2007
- Dr. Chris Quigg, *Fermilab*, Batavia, USA, to Univ. Karlsruhe, May–Jun 2008
- Dr. Evgeny Solodov, *BINP* Novosibirsk, Russia, to Univ. Karlsruhe from Oct–Nov 2007
- Dr. Jozef Vermaseren, *NIKHEF*, Amsterdam, Netherlands, to Univ. Karlsruhe, May–Jul 2008
- Prof. A. A. Pivovarov, *INR* Moscow, to Univ. Siegen, Sep. 2007 to Jan 2008
- Prof. R. Jaffe, *MIT* Cambridge (Mass.), to Univ. Siegen, Nov 2007
- Dr. Gil Paz, *Univ. Princeton* (USA) to Univ. Siegen, Apr. 2008
- Prof. S. Eidelman, *BINP* Novosibirsk, to Univ. Siegen, Jul. 2008

1.4.4 ORGANIZED SCHOOLS

- Events organized by IMPRS, <http://www.mppmu.mpg.de/imprs/>:
 - Particle Physics School Colloquium (monthly)
 - Young Scientist Workshop at Ringberg Castle (July 2008)
 - Block Course: Symbolic and Numeric Programming in High-Energy Physics (June 2008)
 - Soft Skill Seminar (May 2008)
 - Interdisciplinary Symposium - New Frontiers in Science (February 2008)
 - Block Course: Monte Carlo Methods in Particle Physics (November 2007)
 - Young Scientist Workshop at Ringberg Castle (July 2007)
 - Block Course: Supersymmetry at Colliders and in Cosmology (March 2007)
 - IMPRS Applicants Workshop (quarterly)
- Workshop on Particle and Astroparticle Physics, Freudenstadt, 10–12 Oct 2007, organised by Univ. of Karlsruhe,
- Herbstschule Maria Laach *German School for Graduate Students on High Energy Physics*, Sep. 2.-12.2008

1.4.5 GENERAL TRAINING

- *Fundamentals of Scientific Computing*, Munich, May–Jul 2008
- *Computer lab*, Karlsruhe, Oct 2007 – Feb 2008
- *Programming for physicists*, Karlsruhe, May–Jul 2008

1.4.6 ESR HIRED

- Vicent Mateu from Feb 1, 2008, until Jan 31, 2009.

1.4.7 ER HIRED

- Artyom Hovhannisyanyan, hired on Oct 1, 2007, until Sep 30, 2009.

1.4.8 ESR PERSONAL CAREER DEVELOPMENT PLAN TUTORING, ADVISING, OPPORTUNITIES

- Name of fellow: Vicent Mateu
- Workplace: Max-Planck-Institute for Physics, Werner-Heisenberg-Institute, Munich (Germany).
- Name of Supervisor: Prof. Dr. Ulrich Nierste.

BRIEF OVERVIEW OF RESEARCH PROJECT AND MAJOR ACCOMPLISHMENTS EXPECTED

There are two main topics to be covered in the following years: Jet physics and heavy quark mass determinations.

Jet physics: Our idea is to apply the techniques of Effective Field Theories (EFT) to processes taking place at large colliders, namely the International Linear Collider (ILC) and the Large Hadron Collider (LHC). Even though the main purpose of these is to explore the Higgs sector and search for physics beyond the Standard Model (SM), top quarks will be abundantly produced as well, and so they will play a fundamental role in the precise determination of its properties, mass and decay lifetime. As all processes involving quarks, jet production is affected by the inherent non-perturbative QCD effects. One of the most appealing methods for tackling this problem is by means of EFTs, and in particular Soft Collinear Effective Theory (SCET) and Heavy Quark Effective Theory (HQET). The usual benefits of EFTs are a clear separation of scales (in our case, the hard scale Q at which the tops are produced and its own mass when they propagate) and the automatic resummation of large logarithms that could jeopardize the perturbative expansion. These two effects translate into the so called factorization theorems for various event shapes: the matrix element of the process splits (in general as a convolution) into several pieces describing different physical sectors. Each piece can be calculated in a separate EFT and a matching condition between the different EFTs is mandatory for avoiding the aforementioned

large logarithms. The non-perturbative effects are then isolated and encoded in the soft function, which is common to all jet production processes regardless of the mass of the quark. For a very accurate determination of, for instance, the top mass quark it is mandatory to have a very good handle in the theoretical input and so we will make an effort in calculating higher order corrections to the invariant mass distribution for top jets.

Bottom and charm mass determinations: Electron-positron colliders are, in contrast to hadronic ones, very clean in the sense that they have less hadronic background and the center of mass energy is controlled to the few percent level. In particular the quark- antiquark production cross section can be covered through a wide range of energies. It has been a common lore to use these experimental data in combination with QCD sum rules for the determining the quark masses. For heavy quarks a perturbative calculation is indeed a fairly sensible approximation and nowadays it is known up to and including the three loop correction. We plan to push it to the four loop order and to estimate the error by comparison of different treatments for the running coupling constant.

LONG-TERM CAREER OBJECTIVES (over 5 years)

1. Goals: Since during the PhD the fellow has devoted his activity mainly to low and intermediate energies in the light quark sector of the SM, his main goal is to make a firm step towards higher energies and heavy quarks. In the following years the LHC will draw the attention of the major part of the particle physics community and the fellow wants to gain expertise in the necessary techniques in order to make competitive contributions.

2. What further research activity or other training is needed to attain these goals?

The fellow intends to collaborate with Professor Andre Hoang, from the MPI in Munich. Professor Hoang is a world-wide known expert in QCD high energy physics and heavy quark flavours, and in particular in jet processes and mass determinations. So he is the ideal person to work with when trying to approach this research sector. In addition to that the fellow will need to attend many conferences and workshops related to these topics, eventually presenting his own contributions to the fields. This will serve, among other things, to make contact with other scientists very active in the same area.

SHORT-TERM OBJECTIVES (1-2 years)

1. Research results/Anticipated publications: Two loop corrections to soft functions in event shape distributions. Charm and bottom mass determinations from QCD sum rules.

Anticipated conference, workshop attendance, courses, and /or seminar presentations: Seminar at the University of Karlsruhe (Germany), November 2007. Seminar at the University of Prague (Czech Republic), November 2007. Seminar at the IFAE-Barcelona (Spain), December 2007. SCET workshop 2008, Mainz (Germany). Other related workshops such as QCD08 or QCD@work.

2. Research Skills and techniques: Training in specific new areas, or technical expertise etc: The specific techniques the fellow will have to learn are basically, multiloop calculations, Effective field theories such as SCET, HQET and Non Relativistic QCD (NRQCD). In addition to that the fellow also intends to learn German.

3. Research management: No management duties.

Fellowship or other funding applications planned (indicate name of award if known; include fellowships with entire funding periods, grants written/applied for/received, professional society presentation awards or travel awards, etc.): No other funding planned.

4. Communication skills: Steady improvement through scientific talks.

5. Other professional training (course work, teaching activity): The fellow will stay in the MPI Munich where there is no teaching activity going on.

1. Anticipated networking opportunities: The network offers different and equally appealing opportunities. In first place there are regularly organized meetings (once per year) where the scientists belonging to it expose their advances and outlooks. This is a great opportunity of keeping up to date with the current research activity and making contact with active people in the interesting fields of research, translating eventually into collaborations. In addition the network offers the possibility of travelling to the different nodes where network members are world experts in SCET and other EFTs (Aachen, Mainz, Durham).

2. Other activities (community, etc) with professional relevance: In addition to the aforementioned research activity, the fellow might eventually cooperate at the MPI Munich helping in the organization of meetings and workshops, and participating in the seminar set up.

1.4.9 ER CAREER DEVELOPMENT PLAN, TUTORING, ADVISING, OPPORTUNITIES

- Name of fellow: Dr. Artyom Hovhannisyan.
- Workplace: Univ. Karlsruhe, Institut für Theoretische Teilchenphysik, Karlsruhe (Germany).
- Name of Supervisor: Prof. Dr. Ulrich Nierste.

BRIEF OVERVIEW OF RESEARCH PROJECT AND MAJOR ACCOMPLISHMENTS EXPECTED:

We are planning to analyze the $B_s-\bar{B}_s$ system in the Standard Model and beyond. Currently a large experimental effort is devoted to the measurement of the width difference among the two mass eigenstates. Further experiments start to constrain the complex CP-violating phase in the $B_s-\bar{B}_s$ system through bounds on the semi-leptonic CP asymmetry. Both quantities involve the off-diagonal element Γ_{12} of the decay matrix. The theoretical prediction of this quantity is obtained through the Heavy Quark Expansion (HQE), which involves the two expansion parameters α_s and Λ_{QCD}/m_b . Currently Γ_{12} is known to first order in both expansion parameters. We plan to compute the corrections proportional to the product of the two expansion parameters. This calculation will stabilize and improve the theoretical prediction and is necessary for theory to keep up with the accuracy of the future LHCb experiment. The result will have several other applications: One can use it to update the mixing-induced CP asymmetry in the inclusive $b \rightarrow u\bar{u}d$ transitions. More importantly, one can link Γ_{12} to branching ratios into double-charm

final states of B_d mesons. These branching ratios are currently measured at the B factories BaBar and BELLE.

The calculation is difficult and cumbersome, but the ER will profit from the experience of his supervisor with the previous calculation of the α_s corrections. It is planned to publish the result and details of the calculation in a long paper.

LONG-TERM CAREER OBJECTIVES (over 5 years):

1. Goals: The goals are to investigate the properties of mesons containing a b-quark in the Standard Model and possibly in some of its extensions. The topic is known to be an important source of information about the SM and TeV scale physics. The main focus of our research program is a systematic application of QCD technologies (in particular, the calculation of higher order perturbative corrections) to important quantities in b-meson physics to improve the theoretical predictions. The calculation of Γ_{12} can be modified and extended to cover other observables in inclusive decays of b-flavored hadrons. An important example are the QED corrections to semileptonic decays, which are needed to improve on the determination of the element V_{cb} of the Cabibbo-Kobayashi-Maskawa-Matrix.

2. What further research activity or other training is needed to attain these goals?

The calculation of higher order QCD corrections is a difficult task and requires the collaborative work of several experienced people. In addition to the ER and his supervisor, another postdoc, Dr. Marchetti, will join the project. Dr. Marchetti is paid from national sources. The ER already has a solid record of calculations of higher-order QCD corrections. He will profit from the expertise of his host, the TTP in Karlsruhe, on multi-loop calculations. The TTP is at the forefront of this branch of particle physics. As for the required training, the ER needs to learn how to renormalize the four-quark operators involved in the calculation and how to factorize infrared effects. The supervisor will take care of this.

SHORT-TERM OBJECTIVES (1-2 years):

1. Research results: Anticipated publications: 1 publication during the first year and 2 publications during the second year.

Anticipated conference, workshop attendance, courses, and /or seminar presentations: Participation on conferences and meeting conducted by Flavianet, seminars within the university and other conferences and workshops are envisaged, once results are obtained. Further the ER plans to give seminars at other institutions within Flavianet, as a contribution to the networking activity.

2. Research Skills and techniques: Training in specific new areas, or technical expertise etc: The ER is well-trained in his field. He will deepen his knowledge on the renormalisation of the effective field theories used in B physics.

3. Research management: Fellowship or other funding applications planned (indicate name of award if known; include fellowships with entire funding periods, grants written/applied for/received, professional society presentation awards or travel awards, etc.) The ER's salary from 1/10/2007 to 30/9/2009 is funded from the Research and Training Network Flavianet (MRTN-CT-2006-035482). The project further requires computing power, which is provided by the host, the TTP. The ER has his own PC with the necessary computer algebra software. Currently it is

not planned to extend the ER's work in Karlsruhe beyond fall 2009. Application for a new job and/or new funds will be done in due time to ensure a follow-up employment of the ER at another institution.

4. Communication skills: The Institut für Theoretische Teilchenphysik (TTP) organises several weekly internal seminars, where the fellow will practice and improve his skills in scientific presentations. Further he will give talks at physics conferences.

5. Other professional training (course work, teaching activity): In one of the four semesters in Karlsruhe the ER will teach an exercise class for one advanced physics class on a topic in Theoretical Particle Physics.

6. Anticipated networking opportunities: The ER will develop contacts with the lattice QCD groups which compute the hadronic matrix elements entering Γ_{12} . At sub-leading order in Λ_{QCD}/m_b matrix elements have been computed with QCD sum rules in Siegen, which is part of the node Germany-South. Scientific exchange with this group is planned as well. The ER will further attend the relevant topical Flavianet meetings. We also envisage seminar talks at the other nodes which do heavy flavour physics.

7. Other activities (community, etc) with professional relevance: The ER will take German classes starting in May 2008.

1.5 Node No. 5: Italian Institute for Nuclear Physics [INFN])

YEAR 2

1.5.1 OFFERED PH. COURSES (LOCALLY)

- Ph. D. Course on "*The Standard Model*", joint course of Rome-1 and Rome-3 Universities, Winter 2008.
- Ph. D. Course on "*Experimental Particle Physics*", joint course of Rome-1 and Rome-3 Universities, Winter 2008.
- Ph. D. Course on "*Effective Field Theories*", joint course of Rome-1 and Pisa University, Spring 2008.
- Ph. D. Course on "*Effective Field Theories*", University of Naples, Spring 2007.
- Ph. D. Course on "*Heavy Flavours and CKM phenomenology*", joint course of Rome-1 and Rome-3 Universities, Spring 2008.

1.5.2 OFFERED COURSES at ANY LEVEL of interest for the FLAVIANET

- Summer Lectures on "*Physics beyond the Standard Model*", held by Michael Peskin at LNF, Summer 2008.
- Summer Lectures on "*Higgs Physics*", held by Dieter Zeppenfeld, Summer 2008.

1.5.3 VISIT of SENIOR SCIENTISTS from OUTSIDE the NETWORK

- Michael Peskin (SLAC, USA): 15 - 30 June, 2008
- German Valencia (U. of Iowa, USA): 10 - 15 June, 2008
- Francesco Sannino (Bohr Inst., Denmark): 1 - 10 July, 2008

1.5.4 ORGANIZED SCHOOLS

- XII LNF Spring School in Nuclear, Subnuclear and Astroparticle Physics (INFN National Laboratories in Frascati, Italy, from 14th to 18th of May, 2008).

This edition of the School has been devoted to theoretical and experimental developments in high-energy physics in the wake of LHC commissioning.

1.5.5 GENERAL TRAINING

- *Programming in C++*, University of Naples, Spring 2008.
- *English Language Course*, Frascati National Laboratories, Winter/Spring 2008.

1.5.6 ESR HIRED (October 1, 2007-September 30, 2008)

- Miguel Escobedo Espinosa, hired in Milan (INFN Milan) with a 3 months contract started April 3, 2008 (end July 2, 2008).
- Renata Jora, hired in Rome (INFN Rome-1) with a 12 months contract started June 5, 2008 (end June 4, 2009).

1.5.7 ESR already selected and committed (their contract will start next year)

- Pablo Roig Garces, to be hired in Frascati (INFN National Laboratories in Frascati) for 9 months starting in January 2009.
- David Palao, to be hired in Rome (INFN Rome-2) for 12 months starting in September 2009.

1.5.8 ER HIRED (October 1, 2007-September 30, 2008)

- Jernej Fesl Kamenik, hired in Frascati (INFN National Laboratories in Frascati) with a 24 months contract started October 2, 2007 (end October 1, 2009).

1.5.9 ESR PERSONAL CAREER DEVELOPMENT PLAN TUTORING, ADVISING, OPPORTUNITIES

I. *Name of the fellow:* Javier Virto Iñigo

Department: Dipartimento di Fisica, Università di Roma *La Sapienza*.

Name of the supervisor: Luca Silvestrini

Brief overview of research project and major accomplishments expected

The main work to be carried out in the course of the first year is to collaborate with the UT-fit group at the Rome University in two major projects:

- (a) The imminent start-up of the LHC will most probably have a clear impact on flavor physics. It is therefore convenient to review the phenomenology of rare decays and reanalyze the data, the global fits, and the main tensions that persist in the flavor sector of the SM before the start of the LHC. The fellow intends to collaborate with the UT-fit group in the preparation of a report paper providing an overview of the main topics and results regarding flavor physics in the SM and extensions with minimal flavor violation.
- (b) Supersymmetry is a natural and very popular extension of the SM that might be discovered directly at the LHC if, as expected, the superpartners have sub-TeV masses. However, the phenomenology of generic supersymmetric models is very wide due to the arbitrariness of the soft breaking terms or, stated differently, the variety of known and unknown possible mechanisms for supersymmetry breaking. Flavor physics provides a way of discriminating between different generic features of supersymmetric models and extensive research along these lines has been carried out in the past. The fellow will collaborate with the UT-fit group on a global fit to minimal flavor violating MSSM, including constraints from direct searches, the electroweak observables fit, B-physics, dark matter, etc., that should be a useful benchmark as the LHC data arrives.

Besides the projects to be carried out in collaboration with the researchers of the home institution in Rome, the fellow will continue to work with former collaborators, in two main directions:

- (a) The phenomenology of non-leptonic B decays is obscure due to the fact that long distance strong interactions introduce large uncertainties in the predictions. However, these kind of decays contain much information on the nature of CP violation, flavour violation and strong interactions. The fellow has focused on these issues during his PhD, and intends to keep contributing to this field, in particular studying correlations between CP violating observables that are sensitive to contributions from physics beyond the SM.

- (b) Among the extensions of the SM, the models with warped extra dimensions have been a matter of generalized interest from the particle physics community for their natural explanation to the various hierarchy problems. Research on the implications that these recent models have on flavor physics has not exploited all the most interesting possibilities. The fellow intends to introduce himself in this boiling field, and contribute to the study of the flavor of models with extra dimensions. These models will be also in the eye of the hurricane when the LHC starts providing data.

Long-term career objectives (over 5 years)

- (a) *Goals:*
During his PhD the fellow has focused on non-leptonic B decays in the SM and SUSY. In the long term, the fellow intends to extend the frontiers of his expertise to models with extra dimensions and other models of NP. The fellow intends also to introduce himself in the arena of QCD at low energies. The network offers the possibility to interact with experts on these fields and initiate fruitful collaborations.
- (b) *Further research activity and additional training needed to reach these goals:*
The active interaction with expert researchers is the necessary activity to achieve the expertise and maturity required to contribute in a competitive manner in the various fields. This interaction occurs at a first level at the home institute with local researchers, at a second level by attending to schools, conferences and workshops, and at a third level on research visits to other institutions. The fellow intends to work on the three levels by interacting with the local researchers, attending to conferences and workshops related to topics of his interest, and initiating collaborations with researchers of different institutions.

Short-term objectives

- Research results:
 - A) *Anticipated publications:*
 1. A reappraisal of flavor observables before LHC.
 2. Global fit to constrained MFV MSSM.
 3. Correlations of BR and CP-asymmetries in $B_{(d,s)} \rightarrow \pi K$ modes.
 4. Some remarks on the Pade unitarization of low energy amplitudes.
 5. The B_s mixing phase in models with warped extra dimensions.
 - B) *Anticipated conference/workshop attendance and main presentations:*
 1. Talk at EuroFlavor '07 (Paris, November 2007).
 2. IFAE (Bologna, December 2007).
 3. SuperB workshop (Valencia, January 2008).
 4. Planck '08 (Barcelona, May 2008).

5. QCD'08 (Montpellier, July 2008).

6. Attendance of the School on Flavor Physics (Benasque, July 2008).

- Research skills and techniques:

During his stay in Rome the fellow has been trained in the following topics: Supersymmetry and non-perturbative methods in QCD.

- Research management:

The fellow has acquired a basic knowledge of how an European Contract is administered and dealt with in Italy. He has also acquired information about applications for postdoctoral fellowships. As a demonstration of this fact, he has been successfully selected for a two-year INFN postdoctoral fellowship that will start just after his ESR contract.

- Communication skills:

During his ESR fellowship the fellow has had various opportunities to present talks at international conferences, improving his communication skills.

- Other professional training (course work, teaching activities):

During his stay in Rome the fellow has had the opportunity to attend several seminars and colloquia in various fields of physics.

- Anticipated networking opportunities:

The fellow has already participated to the first general meeting of the network in Paris and will participate to the Euroflavour 08 Flavianet meeting in Durham.

- Other activities (community, etc) with professional relevance:

During his stay in Rome the fellow has learned some basic Italian.

II. *Name of the fellow:* Renata Jora

Department: Dipartimento di Fisica, Università di Roma *La Sapienza*.

Name of the supervisor: Antonello Polosa

Brief overview of research project and major accomplishments expected

The main work to be carried out in the course of the first year is to collaborate with the group in Roma working on exotic spectroscopy on both experimental and theoretical aspects. After the latest experimental results to be announced in summer conferences, we plan to review the status of the field in order to understand if there is a compelling evidence of non standard spectroscopy of particles with charm quark.

As a short term project, we are working with Dr Jora to the problem of determining the mass of the lightest tetraquark state in QCD in 1+1 dimensions. QCD in two dimensions,

and in the limit of a large number of colors, has the remarkable property of being a theory with a linearly confining potential for the $q\bar{q}$ pair. Another attractive channel is the antitriplet color one, $\bar{\mathbf{3}}_c$, favoring the formation of diquarks, qq states. Diquarks can be treated as boson fields, $\phi = [qq]$, and one can try to solve the 't Hooft equations (Bethe-Salpeter equations in QCD₂, $N_c \rightarrow \infty$) both in the $q\bar{q}$ and $\phi\phi^*$ cases, i.e. in spinor and scalar chromodynamics respectively. 't Hooft equations are Fredholm integral equations with singular kernels, and their exact solutions are unknown. We are using a variational approach to determine the ground states in both scalar and spinor theories. To determine the mass of the lightest bound tetraquark, we will try to use as an input only the experimental mass of the pion. The 't Hooft model is a strong simplification of QCD but with some connection to the almost one- dimensional flux tube model of quark confinement. For this reason we find interesting the attempt to solve the outlined problem.

Long-term career objectives (over 5 years)

(a) *Goals:*

During his PhD the fellow has focused on the study of light scalar mesons with effective theory approaches. The network offers the possibility to interact with experts on these fields and extend the the knowledge in different directions of particles physics, including experimental groups. At the end of the training period, the fellow is expected to be able to propose new original research projects.

(b) *Further research activity and additional training needed to reach these goals:*

The active interaction with expert researchers is the necessary activity to achieve the expertise and maturity required to contribute in a competitive manner in the various fields. This interaction occurs at a first level at the home institute with local researchers, at a second level by attending to schools, conferences and workshops, and at a third level on research visits to other institutions. The fellow intends to work on the three levels by interacting with the local researchers, attending to conferences and workshops related to topics of his interest, and initiating collaborations with researchers of different institutions.

Short-term objectives

- Research results:

A) *Anticipated publications:*

1. New phenomenological analysis of heavy-quark exotic states.
2. Theroetical models of exotic-states spectroscopy.

B) *Anticipated conference/workshop attendance and main presentations:*

1. Talk at EuroFlavor '08 (Durham, Sept 2008).

2. CKM 2008 (Roma, September 2008).
3. LNF Spring Schol 2009 (Frascati, May 2009).

- Research skills and techniques:

During her stay in Rome the fellow will be trained in the following topics: heavy-meson spectroscopy, data analysis.

- Research management:

The fellow will acquire a basic knowledge of how an European Contract is administered and dealt with in Italy. She will also become familiar about applications for postdoctoral fellowships.

- Communication skills:

During his ESR fellowship the fellow will have various opportunities to present talks at international conferences, improving her communication skills.

- Other professional training (course work, teaching activities):

During her stay in Rome, the fellow will have the opportunity to attend several seminars and colloquia in various fields of physics.

- Anticipated networking opportunities:

The fellow will participate to the general meeting of the network in PEuroflavour 08 Flavianet meeting in Durham.

- Other activities (community, etc) with professional relevance:

During his stay in Rome the fellow has learned some basic Italian.

III. *Name of the fellow:* Miguel Angel Escobedo Espinosa

Department: Dip. di Fisica, Universita Degli Studi di Milano *Name of the supervisors:* Nora Brambilla and Antonio Vairo

Brief overview of research project and major accomplishments expected

The research plan is to study heavy quarkonium physics at finite temperature, using effective field theories (EFT) like non-relativistic QCD (NRQCD) and potential NRQCD (pNRQCD). The importance of this physical system lies in the fact that the relative suppression of this type of particles in heavy ions collisions can be used to measure the temperature of the matter created in this collisions. This conclusion was first presented by Matsui and Satz (Phys. Lett. B 178, 416 (1986)) with a naive model based in Debye screening. Present and future experimental facilities as RHIC and LHC are giving information of this range of temperatures for charmonium (and for bottomonium in a near future), so a more detailed comprehension of this system is needed in order to really understand experimental data and find the temperature of the new state of matter created, and whether it is a weak or

strongly coupled plasma. Until now most studies of this topics have been based on potential models and lattice data, but recently, the work of Laine (hep-ph/0611300) have shown that the physical picture of Debye screening is modified in a very profound way due to the existence of a imaginary part of the static potential that may be bigger than the real part for the relevant temperatures.

Our plan is to use EFT, that have shown their value in zero temperature situation, to calculate in a perturbative way the mass and the potential of heavy quarkonium at finite temperature making as less assumptions as possible, so that the result can be checked with experiments and give us information of the matter created in heavy ion collisions. The starting point of this work will be the paper of Antonio Vairo, Nora Brambilla , Jacopo Ghiglieri and Peter Petreczky(hep-ph:0804.0993) that studies heavy quarkonium with EFT in the static limit, and the paper of Joan Soto and Miguel Angel Escobedo (hep-ph:0804.0691) that studies hydrogen atom with NRQED and pNRQED.

Long-term career objectives (over 5 years)

At the starting of the PhD the fellow have been studying the hydrogen atom situation, as a “toy model” for heavy quarkonium. So the main goal of this collaboration has been to really enter in the QCD calculations, with all the new features that comes from a non-abelian nature of the physical system.

Nora Brambilla and Antonio Vairo are experts in non-relativistic EFT for QCD , and in the last year have been doing research in finite temperature, with a similar approach to that of the hydrogen atom studies of the fellow. For this reason the department of physics of Milan’s University is a very suitable place for the fellow to start studying the more complex heavy quarkonium case.

The techniques and the tools that the fellow has acquired in Milano will be important in enhancing his future career pattern.

Short-term objectives

- Research result:

Anticipated publications: $1/m$ corrections to heavy quarkonium potential at finite temperature and temperature dependent mass determination.

Anticipated conference, workshop attendance, courses, and/or seminar presentation: Euroflavour 08 Flavianet meeting, IPPP, Durham (United Kingdom), september 2008.

- Research skills and techniques:

During his stay in Milano the fellow has been trained in the following topics: Hard Thermal Loops calculations in real time formalism; Nonrelativistic effective field theories; QCD perturbative calculations

- **Research management:**
The fellow has acquired a basic knowledge of how an European Contract is administered and dealt with in Italy. He has also acquired information about applications to the procedures European Commission for grants and postdoctoral fellowships.
- **Communication skills:**
During his stay in Milano the fellow has given several informal talks on the results of his research and this has contributed greatly to build his communication skills.
- **Other professional training (course work, teaching activities):**
During his stay in Milano the fellow has attended several seminars and colloquia in particle physics and in string theory.
- **Anticipated networking opportunities:**
After the end of the fellowship, but due to this, the fellow will participate to the Euroflavour 08 Flavianet meeting in Institute for Particle Physics Phenomenology (IPPP) in Durham, where important contact with scientist of the network will be made.
- **Other activities (community, etc) with professional relevance:**
During his stay in Milano the fellow has improved his knowledge of English and has learned some basic Italian.

IV. *Name of the fellow:* Jernej Fesl Kamenik
Department: Laboratori Nazionali di Frascati
Name of the supervisor: Gino Isidori

Brief overview of research project and major accomplishments expected

The main work to be carried out in the course of the first year is in the following projects in collaboration with researchers at the LNF:

- (a) In view of the accumulating precision measurements of flavour physics observables at the B factories and at the Tevatron, the window for sizable new physics contributions to many processes is shrinking severely. This allows to constrain even the pessimistic scenario of minimal flavour violation (MFV). In collaboration with Tobias Hurth, Gino Isidori and Federico Mescia, the fellow intends to analyze the presently most stringent bounds coming from rare decays on the MFV new physics scenarios in a model independent way both in the one-Higgs doublet case and in the two-Higgs doublet scenario with large $\tan\beta$. Then the implications of these bounds in view of improved measurements in exclusive and inclusive observables in $b \rightarrow s\ell^+\ell^-$ and $s \rightarrow d\nu\bar{\nu}$ transitions at the up-coming LHCb experiment and future flavour factories will be discussed.

- (b) In the Standard Model, scalar contributions to leptonic and semileptonic decays are helicity suppressed, while hypothesis of additional physical neutral/charged Higgses can enhance such scalar contributions and give detectable effects especially in B physics. For the charged Higgs, experimental information on both $Br(B \rightarrow D\tau\nu)$ and $Br(B \rightarrow \tau\nu)$ has already become available and in particular the $B \rightarrow D\tau\nu$ branching ratio measurements will be further improved in the coming years. In collaboration with Federico Mescia, the fellow will evaluate the sensitivity to scalar contributions in semileptonic decays by combining existing experimental information from the B factories with recent lattice estimates of the relevant hadronic quantities. In collaboration with Svjetlana Fajfer and Jan Eeg, the fellow will then evaluate the chiral symmetry breaking effects relevant for future high precision lattice calculations of these quantities and project the sensitivity to scalar contributions in $B_s \rightarrow D_s\tau\nu$ decay.

Besides the projects to be carried out in collaboration with the researchers of the home institution in Frascati, the fellow will continue to work with former collaborators, in the following directions:

- (a) The matrix elements of $\Delta B = 0$ four-quark operators enter several phenomenological studies of which the most important ones are the analyses of the spectra of inclusive semileptonic decays of heavy mesons and the lifetime ratios of heavy-light mesons. In collaboration with Damir Becirevic and Svjetlana Fajfer, the fellow will compare the impact of these power suppressed contributions to inclusive B and D meson observables. Then he will determine the chiral symmetry breaking corrections to the related bag parameters, which can be combined with the forthcoming estimates of the corresponding matrix elements on the lattice to provide a more reliable physics result.
- (b) The up-coming LHC, whose large energy and luminosity make it an efficient top quark factory, will allow for the first time to study rare top quark decays. Among these the flavor changing neutral current $t \rightarrow c$ transitions could provide possible distinctive indications of new physics beyond minimal flavor violation. In collaboration with Svjetlana Fajfer and others the fellow will consider prospective kinematic observables in these decays, which can be analyzed efficiently by the LHC experiments to disentangle different possible new physics scenarios from SM backgrounds using signal distributions.

Long-term career objectives (over 5 years):

- (a) *Goals:*
During his PhD the fellow has focused on the use of effective theories in the description of exclusive D and B meson processes in the SM and possible new physics scenarios. In the long term, the fellow intends to extend the frontiers of his expertise

to many other aspects of particle physics, including physics beyond the SM. He also expect to improve his ability to work in a research team and to interact with experimental groups. At the end of the training period, the fellow should develop the ability to lead a research group by his own.

(b) *Further research activity and additional training needed to reach these goals:*

The active interaction with expert researchers is the necessary activity to achieve the expertise and maturity required to contribute in a competitive manner in the various fields. This interaction occurs at a first level at the home institute with local researchers, at a second level by attending to schools, conferences and workshops, and at a third level on research visits to other institutions. The fellow intends to work on the three levels by interacting with the local researchers, attending to conferences and workshops related to topics of his interest, and initiating collaborations with researchers of different institutions.

Short-term objectives

- Research results:

A) *Anticipated publications:*

1. A new analysis of $B \rightarrow D\ell\nu$ decays
2. Global analysis of MFV in the $\Delta F = 1$ sector.
3. Analysis of spectator effects in inclusive B and D decays.
4. Strategies for CPV studies in $B_s \rightarrow J/\Psi K K$ bar at the LHCb
5. LHC Phenomenology of Higgsless models
6. Phenomenology of Light Neutralinos in RPV MSSM
7. Signatures and constraints on MFV RPV MSSM
8. Analysis of CKM unitarity and new physics hints in the charm sector

B) *Anticipated conference/workshop attendance and main presentations:*

1. Talk at EuroFavor '07 (Paris, November 2007).
2. Attendance at Collider and Flavor Workshop '07 (Geneva, December 2007).
3. Talk at Moriond EW '08 (Moriond, March 2008).
4. Talk at B physics workshop '08 (Cagliari, April 2008).
5. Talk at Planck '08 (Barcelona, May 2008).
6. Seminar at Institute of Theoretical Physics (Karlsruhe, June 2008).
7. Talk at B physics workshop '08 (Capri, June 2008).
8. CKM 2008 (September, Rome).
9. Planck 2009 (May, Padova).
10. EPS HEP '09 (Krakow)

- Research skills and techniques:

During his stay in Frascati the fellow has been trained in the following topics: effective field theories, physics beyond the SM.

- Research management:

The fellow has acquired a basic knowledge of how an European Contract is administered and dealt with in Italy. He has also acquired information about applications for research grants and postdoctoral fellowships.

- Communication skills:

During his stay in Frascati the fellow has had the opportunity to present talks at major international conferences, and has interacted with experienced researchers to improve his communication skills.

- Other professional training (course work, teaching activities):

During his stay in Frascati the fellow has attended several seminars and colloquia in various aspects of particle physics, from coesmology to condensed matter.

- Anticipated networking opportunities:

The will have the opportunity to participate to all the General Meetings of the network and to smaller topical workshops, which stimulate the interactions with other members of the Network.

- Other activities (community, etc) with professional relevance:

During his stay in Frascati the fellow has learned some basic Italian.

1.6 Node No. 6: Poland (University of Silesia, University of Warsaw, Inst. of Nuclear Physics (Polish Academy of Science) Cracow , Andrzej Soltan Insitute for Nuclear Studies (Polish Academy of Science) Warsaw)

YEAR 2

1.6.1 OFFERED PH. COURSES (LOCALLY)

The selected courses listed below, most relevant for FLAVIANet activities, are part of much broader offer from PhD courses at Cracow, Katowice and Warsaw.

- *Introduction to String Theory* , Warsaw, 2007/8
- *Renormalisation, principles and meaning* , Warsaw, 2007/8
- *Quantum Mechanics*, Katowice, 2007/8
- *Extentions of the Standard Model*, Katowice, 2007/8
- *Elements of Quantum Mechanics and Relativity*, Cracow, 2006/7
- *Introduction to Monte Carlo Methods*, Cracow, 2007/8
- *Elementary Particle Interactions: Symmetries and Conservation Laws* , Cracow, 2007/8

- *Neutron stars*, Cracow, 2007/8
- *General Relativity for Physicists*, Cracow, 2007/8

1.6.2 OFFERED COURSES at ANY LEVEL of interest for the FLAVIANET

- *Quantum Field Theory*, Katowice, 2007/8
- *Standard Model*, Katowice, 2007/8
- *Cosmology*, Katowice, 2007/8
- *Relativistic heavy ion interactions*, Cracow, 2007/8
- *Elementary Particle Physics*, Warsaw, 2007/8
- *Introduction to Supersymmetry*, Warsaw, 2007/8
- *Statistics for Physicists*, Warsaw, 2007/8

1.6.3 GENERAL TRAINING

- *Polish Language Course for Foreigners Planning to Study in Poland*, Katowice
- *Polish Courses (at various levels)*, Warsaw
- *Summer School of Polish Language, Literature and Culture*, Katowice
- *History of Physics*, Warsaw
- *Numerical Methods*, Warsaw
- *Object oriented programming*, Warsaw
- *Programming in FORTRAN*, Katowice
- *Programming in C++*, Katowice
- *Computer Simulations and Analysis of Physical Phenomena*, Katowice

1.6.4 ESR already selected and committed (their contract will start this year)

- S. Ivashyn, the contract will start on 1st September 2008, 2 year contract

1.6.5 ESR PERSONAL CAREER DEVELOPMENT PLAN TUTORING, ADVISING, OPPORTUNITIES

- **K. KANISHCHEV, ESR contract, Katowice**

K. Kanishchev has started his one year ESR contact in Katowice on October 17, 2007. His local advisor is Prof. Maria Krawczyk from the Chair of the Theory of Particles and Elementary Interactions at the Physics Faculty at the University of Warsaw. K. Kanishchev receives local guidance and mentorship in his research work both by his advisor, by the other member of the group Ph.D. student Dorota Sokolowska. Training in physics at a general level is offered by the Physics Faculty of the University of Warsaw with a huge variety of seminars, lectures, courses and colloquia.

In particular we notice seminars "Theory of Elementary Interactions" and "Cosmology and Elementary Particles", lectures "Introduction to String Theory" and "Renormalisation, principles and meaning".

Career Development Plan

The research work of Mr. Kanishchev inside the FLAVIANet concerns the study of properties of CP violation in Two Higgs Doublet Model. It was planned to confront some versions of 2HDM with existing data and with expectations at Large Hadron Collider, InterTheory of Particles and Elementary Interactionsnational Linear Collider and Photon Linear Collider. Also analysis of the specific case of 2HDM – the Inert Model was planned.

Training and collaboration

This year K. Kanishchev has attended the following lectures: "Introduction to String Theory" and "Renormalisation, principles and meaning".

He has participated in the following Schools:

Winter School on Strings, Supergravity and Gauge Theories, CERN, January 21 - 25, 2008
FLAVIANet Spring School in Nuclear, Subnuclear and Astroparticle Physics, INFN, Frascati, May 12 - 16, 2008.

He has delivered the following talks/seminars:

"Charge asymmetry of lepton production" – talk at INFN Spring School (Frascati, May 14)

"Different Vacua in 2HDM" – talk at seminar "Theory of Elementary Interactions" at the University of Warsaw.

Also he participated and helped as Scientific Secretary in the three conferences organized by the Chair of the Theory of Particles and Elementary Interactions at Physics Faculty of the University of Warsaw in 2008: 1/ Transfer of Knowledge Meeting – Particle Physics and Cosmology: the Interface (February 2008, Warsaw),
2/ LHC meeting, March 2008 (Warsaw)
3/ ECFA-ILC Meeting (June 2008, Warsaw).

Achievements

This year K. Kanishchev has studied structure of Yukawa sector of 2HDM, properties of

reparametrisation symmetry of 2HDM.

He has been introduced to computer algebra and symbolic manipulation computer program OMEGA (Optimising Matrix Element Generator), establishing contact with its author T.Ohl. He also learnt about Monte-Carlo generators HERWIG, HERWIG++ and WHIZARD. He started to program a new add-on in C++, implementing general Two Higgs Doublet Model into HERWIG++ generator.

He is a co-author of one article submitted to Phys.Rev.D. :

D.A. Anipko, M. Cannoni, I.F. Ginzburg, K.A. Kanishev, A.V. Pak, O. Panella. Charge asymmetries in $\gamma\gamma \rightarrow \ell^+\ell^- + \nu's$ ($\ell = \mu, e$) with polarised photons in the Standard Model. (arXiv:0806.1760)

This is the first-step publication in the long-term project done in collaboration with M. Cannoni and O. Panella (INFN, Perugia, Italy). In this work charge asymmetry in processes like $\gamma\gamma \rightarrow \ell^+\ell^- + \nu's$ is considered. This effect appears even in Standard Model and it is sensitive to New Physics.

During investigation, in collaboration with I.P. Ivanov and I.F.Ginzburg, of a vacuum structure of Two Higgs Doublet Model, the possibility of different sequences of phase transitions in Early Universe was discovered. In particular it was found that the two-stage phase transition with the intermediate charged or spontaneously CP-violating vacuum is possible. The article, reporting this result is in preparation.

1.7 Node No. 7: Nordic (Lund University[ULUND])

YEAR 2

The three institutions all have a full PhD and Master in Physics program. We therefore list only a subset of courses of special interest to the network. Most advanced courses are aimed at both master and PhD students.

1.7.1 OFFERED PH. D. COURSES (LOCALLY)

- Ph. D. Course “*Advanced Quantum Field Theory*”, Lund, January-May 2008.
- Ph. D. course on “*Relativistic Quantum Mechanics and introduction to Quantum Field Theory*”, Lund, September-December 2007.
- Advanced course on “*FYS4170 - Relativistic quantum field theory*”, Oslo, August-November 2007.
- Ph. D. course on “*FYS9120 - Advanced quantum field theory*”, Oslo, Jan-May 2008.
- Ph. D. course on “*Special topics in particle physics*”, Helsinki, Sep-Dec 2007.

1.7.2 OFFERED COURSES at ANY LEVEL of interest for the FLAVIANET

- Master course on “*Theoretical Particle Physics*”, Lund, November 2007-January 2008.
- Master course on “*General Relativity*”, Lund, March-June 2008.
- Master course on “*The general theory of relativity*”, Oslo Jan-May 2008.
- Master course on “*Elementary particle physics*”, Oslo August-November 2007.
- Master course on “*Theoretical particle physics*”, Helsinki, September-December 2007.
- Master course “*Introduction to quantum field theory*”, Helsinki, September-November 2007
- Master course “*Path Integrals*”, Helsinki, January-March 2008.
- Master course “*General relativity*”, Helsinki, January-May 2008.

1.7.3 GENERAL TRAINING

- Introduction to PhD Studies, Lund
- Seminar series in Experimental and Theoretical Particle Physics: exists in all three institutes: Lund, Oslo and Helsinki.

1.7.4 PERIODS SPENT by MEMBERS of the FLAVIANET in OTHER NODES/SUBNODES

Jan Eeg 7 10 (Ljubljana) 26/2-13/3/2008

1.7.5 COURSES/TRAINING ACTIVITIES BY MEMBERS OF THE NETWORK in DIFFERENT NODES/SUBNODES

- Talk by J. Eeg in Ljubljana, 5 March 2008, *Short and long distance strong interaction effects in $B \rightarrow D\pi$ decays*

1.7.6 ESR hired October 1, 2007- September 30, 2010)

- Ilaria Jemos, hired for 36 months, started October 1, 2007 until end of September 2010.

1.7.7 ESR PERSONAL CAREER DEVELOPMENT PLAN

- **Ilaria Jemos, ESR contract, Lund**

Brief overview of research project and major accomplishments expected:

The planned project is performing a new fit of the Chiral Perturbation Theory parameters at NNLO taking into account the more sophisticated models for the higher order low-energy-constants now available. We will also try to see if we can find more nontrivial relations between observables at NNLO order.

Long-term career objectives (over 5 years):

1. Goals: PhD degree
2. Further research activity or other training is needed to attain these goals: 90 ECTS credits of advanced courses and 150 ECTS credits of research.

Short-term objectives (1-2 years):

1. Research results
 - Anticipated publications: None in the first year, then a first one with a preliminary new fit.
 - Anticipated conference, workshop attendance, courses, and /or seminar presentations: November meeting in Orsay, Kaon working group meeting in June in Capri and Benasque Flavianet training school next summer.
2. Research Skills and techniques: Training in specific new areas, or technical expertise etc: Studying Chiral Perturbation Theory and associated techniques.
3. Research management: Fellowship or other funding applications planned (indicate name of award if known; include fellowships with entire funding periods, grants written/applied for/received, professional society presentation awards or travel awards, etc.)
4. Communication skills: Introductory PhD Course which includes first training on giving seminars and writing papers.
5. Other professional training (course work, teaching activity): Statistical mechanics, electrodynamics.
6. Anticipated networking opportunities : see under point 1
7. Other activities (community, etc) with professional relevance: visit to Pavia university to complete paper based on master thesis.

1.8 Node No. 8: France (CNRS)

YEAR 2

1.8.1 OFFERED PH. COURSES (LOCALLY)

Several PhD programmes are offered in Orsay, Marseille and Prague, in particle and nuclear physics, either on experimental or on theoretical aspects, among which one can highlight

-
- Quantum Field Theory, second year Masters course (Oct 07-Jan 08, Orsay)
 - Particles and symmetries, second year Masters course (Oct 07-Jan 08, Orsay)
 - Introduction to cosmology, second year Masters course (Oct 07-Jan 08, Orsay)
 - High-energy astrophysics, second year Masters course (Oct 07-Jan 08, Orsay)
 - Weak interaction and unification, second year Masters course (Mar 08-Jun 08, Orsay)
 - Strong interaction, second year Masters course (Mar 08-Jun 08, Orsay)
 - Neutrinos, second year Masters course (Mar 08-Jun 08, Orsay)
 - Relativity and gravitation, second year Masters course (Mar 08-Jun 08, Orsay)
 - Relativistic quantum field theory, second year Masters course (L. Lellouch, Oct 07-Jan 08, Marseille)
 - Advanced quantum field theory, second year Masters course (L. Lellouch, Jan-Mar 08, Marseille)
 - The standard model and beyond, second year Masters course (Jan-Mar 08, Marseille)
 - Advanced quantum mechanics, second year Masters course (Oct 07-Jan 08, Marseille)
 - Particle physics, second year Masters course (Oct 07-Jan 08, Marseille)
 - Introduction to astroparticle physics and cosmology, second year Masters course (Oct 07-Jan 08, Marseille)
 - Experimental particle physics, second year Masters course (Jan-Mar 08, Marseille)
 - Experimental astroparticle physics, second year Masters course (Jan-Mar 08, Marseille)
 - General relativity, second year Masters course (Jan-Mar 08, Marseille)
 - Geometry and gauge theories, second year Masters course (Jan-Mar 08, Marseille)
 - Observational cosmology, second year Masters course (Jan-Mar 08, Marseille)

1.8.2 OFFERED COURSES at ANY LEVEL of interest for the FLAVIANET

- Hybrid Monte Carlo algorithm for PhD students, Ph. Boucaud (4-5 December 2007, Grenoble, France)
- Experimental and theoretical particle physics, M1 and M2 courses, M.H. Schune (February 2008, Kiev, Ukraine)
- Combinations of observables in flavour physics, first School of Statistics, J. Charles (30 Jun-4 Jul 2008, Strasbourg, France)
- The Standard Model and beyond, PhD Trans-European School of High Energy Physics, S. Descotes-Genon (3-9 Jul 2008, Buzymerovka, Sumy region, Ukraine)
- Flavour physics, PhD Trans-European School of High Energy Physics, M.H. Schune (3-9 Jul 2008, Buzymerovka, Sumy region, Ukraine)

1.8.3 COURSES/TRAINING ACTIVITIES BY MEMBERS OF THE NETWORK in DIFFERENT NODES/SUBNODES

- 1 PhD student (Benjamin Haas) and 1 ESR (Niels Offen) took part in the Benasque *Summer School on Flavour Physics* (13-25 July 2008, Benasque, Spain).

1.8.4 VISIT of SENIOR SCIENTISTS from OUTSIDE the NETWORK

- Mikhail Shifman (Univ. of Minnesota, USA) has been staying at LPT Orsay since Spring 2008 under an International Chair of Research Blaise Pascal (French state chair). He gave an inaugural lecture on superconductivity and quark confinement in June 2008, and he will give six lectures on *the Polyakov model of confinement* for M2 students in October 2008.
- Stephen Sharpe (Univ. of Washington, USA) visited CPT Marseille from June 23 to July 22, 2008, as an invited professor of the Université de la Méditerranée. He gave three ninety-minute lectures on *Applications of chiral perturbation theory to lattice QCD* to 13 graduate students and postdoctoral fellows and 17 scientists from France, Germany and Spain.
- Rahul Sinha (Chennai, India) will visit CPT Marseille from 31st August to September 2nd 2008, for collaboration and a seminar.

1.8.5 ORGANIZED SCHOOLS

Members of the node 8 took part in the organisation of three schools for PhD students

- Block course on Lattice Simulations of Quantum Fields (26 March-1st April 2008, Orsay)

Flavianet Members participating: D. Becirevic (organiser), P. Boucaud (lecturer) (node 8), V. Lubicz (node 5),

Participation : 20 ph. d. students, 3 postdocs, 10 scientists

Coming from: Germany, France, USA, UK.

- First School of Statistics, (30 June-4 July 2008, Strasbourg, France)

Flavianet Members participating: O. Leroy (organiser), J. Charles (lecturer) (node 8),

Participation : 65 PhD students, 15 scientists

Coming from: mainly France, USA and CERN.

- Trans-European School on High-Energy Physics (3-9 July 2008, Buzymerovka, Sumy region, Ukraine)

Flavianet Members participating: A. Stocchi (organiser), M.H. Schune (organiser and lecturer), S. Descotes-Genon (lecturer) (node 8)

Participation : 40 ph. d. students, no postdocs, 10 scientists

Coming from: Poland, Ukraine, Russia, Roumania, Hungary, France.

1.8.6 GENERAL TRAINING

- English and French language courses provided by CNRS (Orsay) and University Paris-Sud 11 (Oct 07-Jun 08)
- Access to “Formation permanente” courses offered by CNRS (Orsay, Marseille)
- Weekly seminars on particle physics from September to July in Orsay, Marseille and Prague
- Monthly seminars among PhD students from September to July in Orsay, Marseille.

1.8.7 ESR HIRED (October 1, 2007-September 30, 2008)

- Nils Offen, hired in Orsay, started his contract 1st August 2007 for 2 years.

1.8.8 ESR already selected and committed (contract to start next year)

- Pablo Roig, hired in Orsay, will start 1st October 2009 for 1 year.

1.8.9 ER already selected and committed (contract to start next year)

- Alberto Ramos, hired in Marseille, will start 1st October 2008 for 2 years.

1.8.10 ESR PERSONAL CAREER DEVELOPMENT PLAN TUTORING, ADVISING, OPPORTUNITIES

- **Nils Offen, Orsay**

N. Offen has started his two-year ESR contract in Orsay on Aug 1st 2007. His local advisor is Dr S. Descotes-Genon, with further local guidance and help from Drs. D. Bećirević, O. Pène, L. Oliver and E. Kou, as well as from Ph.D. students (E. Chang, B. Haas, B. Malaescu). Experimental aspects of flavour physics are covered through discussions with A. Stocchi, M.H. Schune, P. Roudeau, Y. Ahmis (LAL Orsay). As a member of the particle physics group of LPT Orsay, Nils Offen has the opportunity to take part in the regular discussions between theorists and experimentalists on the Orsay campus. If needed, further background on basic physics can be easily obtained through the courses and seminars provided by the Department of Physics and the laboratories on the campus of Orsay.

Career Development Plan

The research work of N. Offen inside the Flavianet concerns sum rules on the light cone applied for B -decays at present. The career development plan has been elaborated together with his local advisor to provide N. Offen tools to tackle further issues on the non-perturbative aspects of heavy-quark physics (introduction to lattice methods, effective theories) and to give him an introduction to experimental issues in flavour physics.

Currently N. Offen is working on two projects. The first project (with S. Descotes-Genon) concerns the renormalization of leading light-cone distribution amplitudes of the B -meson once higher Fock states are taken into account. The second project (with D. Bećirević) consists in reassessing the use of QCD sum rules within the framework of heavy quark effective theory (HQET). Both projects cover issues of theoretical as well as phenomenological interests and provide N. Offen the opportunity to learn methods used to tackle a wide variety of problems in Heavy-Flavour Physics. N. Offen plans also to start another project with his home institution in autumn 2008, which deals with the use of light-cone sum rules in the sector of the charm quark.

Training and collaboration

Since he was hired in August 2007, N. Offen has kept a steady link with his home institution (Univ. of Siegen) through several stays, allowing him to finish a project on $B \rightarrow \pi$ form factors and to prepare a new project on $D \rightarrow \pi$ and $D \rightarrow K$ form factors in collaboration with Dr. A. Khodjamirian. He presented his results at the EuroFlavour 07 conference (Orsay, Nov 2007) under the title V_{ub} and $B \rightarrow \pi$ form factors from QCD sum rules revisited. He has been invited to give a talk at the international workshop on the CKM matrix in Rome in Sep. 2008 concerning theoretical uncertainties of QCD sum-rule calculations.

At the local level, in addition to collaborating with Drs. S. Descotes-Genon and D. Bećirević, N. Offen participated at the local seminars in particle physics, and he gave two lectures on flavour physics and QCD sum rules for PhD students. At the Flavianet school on Flavour Physics (July 2008, Benasque), he will give tutorials for PhD students.

Achievements

Besides learning the basics of French via courses provided by CNRS, N. Offen has finished a project under the title *Light-cone sum rules for $B \rightarrow \pi$ form factors revisited* [Duplancic et al., JHEP 0804:014,2008]. He has completed his PhD thesis *B-Zerfallsformfaktoren aus QCD-Summenregeln* (in German) which he defended successfully Jan 25 2008 at the University of Siegen. He is currently working on two projects with Drs. S. Descotes-Genon and D. Bećirević concerning the research objectives defined in his CDP, together with further projects in collaboration with his home institution.

1.9 Node No. 9: Switzerland (Universität Bern (UBERN))**Year 2****1.9.1 OFFERED PH. COURSES (LOCALLY)**

- At the University of Bern we offer a series of “Special topic courses” with about 12 hours of lectures over four weeks for PhD students. During the academic year 2007/08 we had:

“Particle physics of the early universe”, Uwe-Jens Wiese (Bern)

“Introduction to grand unified theories” Christopher Smith (Bern)

“The standard model”, Christoph Greub (Bern)

- At the University of Zurich:

“Flavour Physics (theoretical and experimental aspects)”, Tobias Hurth (CERN-Zurich) and Urs Langenegger (ETH-PSI)

**1.9.2 VISIT of SENIOR SCIENTISTS
from OUTSIDE the NETWORK**

M. Sainio, Institut für theoretische Physik, Universität Helsinki, Helsinki, Finnland, 28.2.08

A. Rusetsky, Institut für theoretische Physik, Universität Bonn, Deutschland, 31.7.-11.8.07, 14.-19.9.07, 9.-14.4.08, 30.6.08

A. Nyffeler, Harish-Chandra Research Institute, Allahabad, Indien, 30.5.08, 5.5.08, 23.6.-4.7.08

L. Nemenov, CERN, Genf, 16.4.08

B. Joffe, Institut for theoretical Physics (ITEP), Moskau, Russland, 20.-24.8.07

A. Hasenfratz, Dept. of Theoretical Physics, University of Colorado, Boulder, USA, 13.-16.5.08

S. Gevorkyan, CERN, Genf, 10.-11.4.08

T. Ewerth, Istituto Nazionale di Fisica Nucleare, Torino, Italien,
23.10.07, 14.-16.11.07, 13.6.08

A. Bernstein, MIT, Cambridge, USA, 29.-30.5.08

H. Asatrian, Physics Institute, Yerevan, Armenien,
13.11.-13.12.07, 2.6.-4.7.08

A. Alok, Tata Institute of Fundamental Research, Mumbai, Indien,
5.-8.6.08

1.9.3 GENERAL TRAINING

- The University of Berne, Lausanne and Zurich have a wide offer of language courses, like German for foreigners at various levels and Scientific writing in English.
- Moreover they offer courses about different aspects of management for people working in the academic/scientific world.

1.9.4 ESR HIRED (October 1, 2007–September 30, 2008)

- Simone Bifani, hired in Bern on January 1. 2008, ESR 2 years contract

1.9.5 ESR PERSONAL CAREER DEVELOPMENT PLAN TUTORING, ADVISING, OPPORTUNITIES

• S. Bifani, ESR contract, Bern

Simone Bifani has started his two year ESR contract in Bern on January 1. 2008. Local advisor is Augusto Ceccucci.

• E. Passemar, ESR contract, Bern

During her first year as ESR in Bern, Emilie Passemar has worked on his PhD thesis, has given important contributions to the Kaon Working group (and has reported on the activity of this working group at the BEACH08 Conference in South Carolina in June 2008), and has started a new project in collaboration with G. Colangelo and Stefan Lanz on the dispersive treatment of $\eta \rightarrow 3\pi$. She has had regular discussions and exchanges also with other senior members of the node, like J. Gasser, H. Leutwyler and C. Smith on different aspects related to her PhD work. At the University of Bern she has attended graduate courses on “Particle physics of the early universe” and on “Grand unified theories”. She has had german courses for beginners. *Career Development Plan*

E. Passemar will finish her PhD in the coming months. Afterwards she will intensify her work on $\eta \rightarrow 3\pi$ and have a chance to start new projects. As already during last year,

E. Passemar will be given the opportunity to present her achievements locally, in network meetings and at international conferences.

Training and collaboration

At the University of Bern E. Passemar can attend graduate courses in particle physics on various topic of interest and also language courses (German and scientific english). We had planned her participation to the Flavianet Summer school on flavour physics in Binasque (which she unfortunately had to cancel in order to complete her PhD thesis within the deadline, which was just after the school).

Achievements

E. Passemar has completed two new papers during last year, one with her advisor in Orsay and other collaborators also belonging to the network, and the other with the Flavianet working group on Kaon decays. The results of this working group have been used by the Particle Data Group.

1.10 Node No. 10: Austria (Universität Wien)

Year 2

1.10.1 OFFERED PH. COURSES (LOCALLY)

This node offers a complete programme of PhD courses in all fields of theoretical and experimental physics. The most relevant ones for the FLAVIANet topics are:

- Seminar: Particle Physics, winter term 2007/2008, summer term 2008
- Lectures on Neutrino Physics, winter term 2007/2008
- Seminar: Noncommutative Quantum Field Theory, winter term 2007/2008
- Seminar: Noncommutative Geometry and Strings, summer term 2008

1.10.2 OFFERED COURSES at ANY LEVEL of interest for the FLAVIANET

- Course: Electroweak Physics at the LHC, winter term 2007/2008
- Seminar: Electroweak Symmetry Breaking (Higgs Mechanism), summer term 2008
- Course and Exercises: Particle Physics 1, winter term 2007/2008
- Course and Exercises: Particle Physics 2, summer term 2008
- Course: Lie-groups and Lie-algebras for Physicists, summer term 2008
- Course: Special Relativity 2 (Representation Theory of Lorentz and Poincare Group), summer term 2008

- Course: Relativity 3 (Gravitation and Quantum Theory), winter term 2007/2008
- Course: Relativity and Cosmology 2, summer term 2008
- 4th Vienna Central European Seminar on Particle Physics and QFT (Commutative and Noncommutative Quantum Fields), November 30 - December 2, 2007

1.10.3 VISIT of SENIOR SCIENTISTS from OUTSIDE the NETWORK

- Stefan Dittmaier (MPI Munich), winter term 2007/2008
- Alexei Yu. Smirnov (ICTP Trieste), October 2007

1.10.4 GENERAL TRAINING

- Language Courses: German
- Practical Course: Computers in Theoretical Physics, winter term 2007/2008
- Practical Course: Scientific Computing, summer term 2007

1.10.5 ESR

- Martin Zdráhal, January 2008 – December 2009

1.10.6 ESR PERSONAL CAREER DEVELOPMENT PLAN TUTORING, ADVISING, OPPORTUNITIES

- **Martin Zdráhal, ESR contract, Vienna**

Martin Zdráhal has started his two-year ESR contract on January 1, 2008. His local advisor is Helmut Neufeld with additional local guidance by Gerhard Ecker.

Career Development Plan

Martin Zdráhal is presently finishing the work on his doctoral thesis which he had started in Prague under the supervision of J. Novotný. He is working on the dispersive approach to chiral perturbation theory. In collaboration with K. Kampf, M. Knecht and J. Novotný he is applying this method to the treatment of cusp effects in $K \rightarrow 3\pi$ decays. After completion of his PhD he will extend his research activity in other directions, in particular in studies of electromagnetic effects in chiral perturbation theory and the determination of low-energy constants with large- N_c methods. For both research directions he finds the necessary local expertise. He will be able to present the results of his research in local seminars, in network meetings and at international conferences.

Training and collaboration

At the University of Vienna he can attend graduate courses on various topics of interest, seminars, informal discussions of the members of the particle physics group and German

courses. He finds the opportunity for research collaborations inside and outside this node. At present, he is involved in an active collaboration with J. Novotný (node 8), M. Knecht (node 8) and K. Kampf (presently at Paul Scherrer Institute, Villigen, Switzerland).

Achievements

Since Martin Zdráhal has arrived in Vienna he has completed one paper with his advisor in Prague. He has presented the current status of his work on $K \rightarrow 3\pi$ decays at the FLAVIANet Kaon Workshop in Capri and at the local particle physics seminar in Vienna. He has attended the QCD 08 conference in Montpellier giving him also the opportunity to establish valuable contacts with experimentalists working in kaon physics. His visit of the FLAVIANet group in Marseille allowed him fruitful scientific discussions on the $K \rightarrow 3\pi$ research project. Martin Zdráhal was actively participating in the local seminar on “Electroweak Symmetry Breaking” giving a talk on “Extensions of the Standard Model with Extra Dimensions”. Finally, he has also passed the final exam of his German course (level B1) at the University of Vienna with excellent grades.

1.11 Node No. 11: Germany North ((DESY, Zeuthen))

The Universities of Berlin (Humboldt), Bonn, Mainz and Münster offer a complete programme of Ph.D courses in theoretical and experimental particle physics including nuclear physics at Bonn and Mainz. We list here courses which are particularly relevant for FLAVIANet.

YEAR 2

1.11.1 OFFERED PH. COURSES (LOCALLY)

- Ph. D. course + exercises: Quantum Field theory I in SS 2008
- Ph. D. course + exercises: Theoretical Hadron Physics in WS 2007/08
- Ph. D. Tutorial on “*Algorithms for dynamical fermions in lattice QCD*” Berlin, October 2007 - February 2008
- Ph. D. Tutorial on “*Extra dimensions*” Berlin, April 2008 - July 2008
- Ph. D. Course on “*Quantum Field Theory and Quantum Chromodynamics*”, Münster, April - July 2008
- Ph. D and Research Seminar on “*Quantum Field Theory*”, Münster, October 2007 - February 2008 and April - July 2008
- Ph. D. and Student Tutorial on “*Theoretical Nuclear and Particle Physics*”, Münster, October 2007 - February 2008 and April - July 2008

1.11.2 OFFERED COURSES at ANY LEVEL of interest for the FLAVIANET

- Lecture + exercises: Quantim Field theory II in WS 2007/08
- Seminar “Hadron physics with antiprotons,” WS 2007/08
- Course on “*Introduction to the standard model*” Berlin, October 2007 - February 2008
- Course on “*Quantum field theory I*” Berlin, October 2007 - February 2008
- Course on “*Physics at LHC*” Berlin, October 2007 - February 2008
- Course on “*Quantum field theory II*” Berlin, April 2008 - July 2008
- Course on “*Flavour physics*” Berlin, April 2008 - July 2008
- Course on “*Introduction to the Standard Model of Elementary Particle Theory*”, Münster, October 2007 - February 2008
- Student Seminar on “*Path Integrals in Quantum Mechanics and Field Theory*”, Münster, October 2007 - February 2008
- Student Seminar on “*Particles and Fields: Symmetries and Conservation Laws*”, Münster, April - July 2008

1.11.3 VISIT of SENIOR SCIENTISTS from OUTSIDE the NETWORK

- J. Myers, Washington University St. Louis, visiting Münster 09/12/07 - 11/12/07
- I. Montvay, visiting Münster in April 2008
- F. Bruckmann, University of Regensburg, visiting Münster 24/06/08 - 26/06/08

1.11.4 ORGANIZED SCHOOLS

- Workshop on “*Perspectives and Challenges for Full QCD Lattice Calculations*”, Trento, Italy, 05 - 09 May 2008, 50 Participants, organized by F. Farchioni, L. Scorzato and U. Wenger

1.11.5 PERIODS SPENT BY MEMBERS OF THE FLAVIANET IN OTHER NODES/SUBNODES

- 28/11/07 - 29/11/07 Training on twisted mass QCD by Gernot Münster at University of Mainz
- 22/01/08 - 23/01/08 Training on one-flavour lattice QCD by Federico Farchioni at DESY, Zeuthen

- 13/02/08 - 15/02/08 Training on charm physics by Jochen Heitger at University of Mainz
- 02/04/08 - 04/04/08 Training on HQET by Jochen Heitger at Tor Vergata, Rome (Node 5)
- 18/06/08 - 20/06/08 Training on HQET by Jochen Heitger at DESY, Zeuthen

1.11.6 ESR HIRED

- Francesco Virota, hired in DESY in April 2008, ESR 21 months contract
- Michael Donnellan, hired in DESY in July 2008, ESR 27 months contract

1.11.7 ESR PERSONAL CAREER DEVELOPMENT PLAN TUTORING, ADVISING, OPPORTUNITIES

- Francesco Virota

Francesco Virota has a background as a theoretical physicist, working in his Diplom thesis on classical quantum field theory out of equilibrium. The overall plan for his career is to learn the physics of heavy quarks in the Standard Model and in particular the non-perturbative dynamics of strong interactions of these quarks. He will work on a PHD thesis dealing with the development of algorithms as well as their application in the numerical simulations of these quarks.

Under the supervision of Rainer Sommer, and in the first two months, he will study lattice gauge theory starting with text books. Recent review articles on the simulation of dynamical fermions such as the one by A. Kennedy will be studied. In months 3-4, the literature on domain decomposition and multi-mass solvers in lattice QCD will be critically reviewed. Out of these studies a practical algorithm for adding mass-non-degenerate quarks to the known 2-flavor algorithm based on domain decomposition by Martin Lüscher will be developed in months 5-6. Its implementation into the public domain code [<http://luscher.web.cern.ch/luscher/DD-HMC/index.html>] will be planned in month 7 and carried out in months 8-12.

Months 13-21 are reserved for a study and tuning of the algorithmic parameters in simulations of QCD with one flavour of a large quark mass as well as in QCD with 2 light flavours and 1 heavier one. In parallel to this and in collaboration with other members of the node cutoff effects of heavy quarks will be studied in perturbation theory in order to understand how small the lattice spacing has to be in order to allow for a meaningful simulation of a dynamical charm quark.

The FLAVIANet contract of Francesco Virota will end after month 21 and he will finish his PHD work with a grant by the German DFG. Depending on the outcome of the previous studies the effects of a heavy quark on the running of the strong coupling constant or on Heavy Quark Effective Theory matrix elements will then be investigated numerically.

In parallel to this research plan, Francesco Virota will visit classes on the Standard Model, lattice gauge theory, Gravity and others at the Humboldt University and participate in all

activities of the planned Graduierten Kolleg. He will take part in the FLAVIANet meetings, the FLAVIANet schools and when appropriate will visit other nodes, in particular the Swiss node (CERN) to get training on dynamical fermion algorithms.

It is planned to finish the PHD in February 2011.

- Michael Donnellan

Michael Donnellan has a background as a theoretical physicist, working on his PHD thesis on meson distribution amplitudes as well as non-perturbative renormalization in the MOM scheme.

In Zeuthen he will finish his PHD thesis. He will then continue working on meson distribution amplitudes and learn about the non-perturbative renormalization in the Schrödinger functional scheme for which there are top experts at node Germany North of the network.

He will get training in the non-perturbative treatment of HQET, which was developed in the node Germany North. Depending on the progress achieved here and at other places, he may enter a project on the semileptonic decays of $B \rightarrow \pi l \nu$ for the precision extraction of V_{ub} or $B \rightarrow D l \nu$ for the precision extraction of V_{cb} . In these projects the non-perturbative treatment of HQET will be essential. Applications will initially be for the quenched approximation, but together with other members of the node, in particular calculations with two quark flavours are being carried out.

Furthermore, F. Virotta, another ESR fellow, will develop an algorithm and code for simulations of QCD with one flavour of a large quark mass as well as in QCD with 2 light flavours and 1 heavier one. Michael Donnellan will acquire knowledge on these techniques as well.

In parallel to this research plan, Michael Donnellan will participate in special courses at the Humboldt University and participate in activities of the planned Graduierten Kolleg. He will take part in the FLAVIANet meetings, the FLAVIANet schools and when appropriate will visit other nodes as well as Münster and Mainz which belong to the node Germany North.

Michael Donnellan will take German classes here at DESY to further come to a professional level in German.

By the time he finishes his contract in 2010 he will have acquired knowledge in a broad range of aspects of lattice gauge theory. He will thus qualify as an experienced postdoc in the field.

2 Outreach Activities

Science, and in particular physics, does not raise the interest of the general public as much as it should, considering the challenging questions it addresses to Nature and its far-reaching

impact on everybody's life and environment. To raise the public awareness of particle physics and help increase the attractiveness of science among students, members of the *FLAVIANet* have put forward a series of activities. For each kind of activity, we will only highlight some of the contributions done inside the network, bearing in mind that all the nodes are involved at one level or another in outreach activities and that we cannot list all their contributions.

2.1 Outreach activities at the level of the network

Several actions were launched through the *FLAVIANet* network, either during *FLAVIANet* events or between nodes of the network. A first step has consisted in setting up a web page on the *FLAVIANet* web site, collecting various outreach activities from the nodes of the network together with resources of interest, both for the researchers of the network involved in outreach and for the general public looking for information on particle physics.

During the time of the general meeting of the network, the Euroflavour 07 conference (Nov. 07, Orsay, France), an outreach conference was proposed in French by a physicist of the network, P. Roudeau (LAL Orsay) for the researchers and students of the campus of Orsay, but also for the inhabitants of the neighbouring towns. This colloquium on the history and the present of particle physics was organised in the framework of the local committee of the French Physical Society (SFP). This successful conference prompted the organisation of a second colloquium two months later in the same framework, more focused on the LHC Physics, by M. Giovannozzi (CERN).

Another inter-node outreach activity occurred in September 2007. G. Colangelo (Node 9) came to Frascati (node 5) to give a talk on "Herr Einstein, Mr. Higgs e il mistero della massa" during the European Researchers' Night organised in the LNF laboratories.

2.2 Science week and open days

All the nodes of the *FLAVIANet* network take part in national Science weeks or European events. In these events, members of the network have an active role in promoting particle physics through conferences and animations aimed at schools. Among these initiatives, one can highlight:

- In the Science Week in November 2007, the IFIC group (Valencia, node 1) organised several "Scientific Cinema" sessions for secondary school pupils.
- In September 2008, the Frascati laboratories was open to the general public members of *FLAVIANet* belonging to the KLOE experiment, have guided visitors through the laboratories to explain the goals and methods of research in particle physics.
- Laboratories on the Orsay campus (node 8) take part regularly in the French Science Week (Fête de la Science), in particular its edition in October 2008. Members of the network belonging to LAL and LPT laboratories gave outreach conferences to secondary school pupils, using as a support the journal "Élémentaire" described below.
- The Desy research center (Berlin, node 11) organised an open day during the "8. Langen Nacht der Wissenschaften", in June 2008.

More local public events are also frequent, for instance a colloquium entitled “From radioactivity to LHC” in Marseille in February 2008 (node 8), a “Physics for breakfast” morning in July 2008 in Berlin (node 11), evening lectures in public observatories in Münster (node 11) . . .

In addition, we mention the IPPP Institute in Durham (node 3), which is very active in promoting family shows to explain the goals of the LHC to a broad audience. A first show, called “Dinosaurs from Dust - The World’s Most Powerful Particle Smasher”, had its premiere at York Museum during the 2008 Science Week before being open in the Durham Physics Department. A second project, “3D LHC”, is currently developed : the goal is to use stereoscopic projection to create an immersive 3D experience that brings excitement into the classroom to promote understanding of the complex and abstract concepts of particle physics, and to enthuse the audience by “taking them there” and making the LHC reality.

2.3 School-oriented activities

Beside these events, long-run programs of visits for school pupils are organised in several of the nodes of the network, often relying on an on-line booking through a web interface in order to provide an easy access for interested teachers. Such initiatives take place for instance at the IFIC center (Valencia, node 1), the ACO accelerator in relation with the LAL laboratory (Orsay, node 8), the Desy-Zeuthen centre and the Humboldt university (Berlin, node 11) . . . Another successful program consists in Masterclasses, one-day events mixing lectures, exercises and visits for pupils and (sometimes) teachers. Such events are regularly organised in Durham, Oxford and Southampton (node 3), at the University of Silesia (Katowice, node 6), the University of Vienna (node 10), the Desy-Zeuthen centre and the Humboldt university (Berlin, node 11) as well as the University of Münster (node 11), attracting hundreds of pupils. There are also longer Summer Schools, for instance in Durham (node 3) and Helsinki (node 7), lasting one or two weeks, for more limited audience (from twenty to forty students).

A key partner in outreach activities aimed at schools consists in teachers. This prompted several nodes to provide yearly courses for high-school teachers, so that they can improve their own understanding of “hot” research themes in particle physics and share this up-to-date knowledge with their pupils. This is in particular the case for the groups belonging to Frascati laboratories (node 5), the University of Helsinki (node 7), the CPT centre in Marseille (node 8), the University of Vienna (node 10), the University of Münster (node 11).

There are also more local initiatives, for instance:

- The UK teams (node 3) have involved postgraduate in the organisation of a series of junior Cafés Scientifiques in local secondary schools. This scheme aims to promote student interaction, critical thinking and discussion of scientific ideas and concepts and their social and ethical implications. They also provide scientists with the opportunity to introduce their subject to school students in a relatively informal setting.
- The group at the University of Silesia (node 6) co-organise every year with the Youth Palace in Katowice the “Grzegorz Bialkowski competition” for high-school Polish students who have to write an essay on particle physics or astrophysics. They also organise an

event called “ π - fest” each year, with popular science lectures for high school students and teachers, competitions, experiments . . . , where the FLAVIANet group gave lectures on the LHC, the Standard Model and the Linear Collider.

- Open days for high schools are often the opportunity for FLAVIANet members to give introductory talks to particle physics. For instance J. Bijnens (node 7) gave a talk “On the connection between magnets, the Higgs particle and a V.I.P. party” in March 2007, in front of about 150 attendants, whereas S. Descotes-Genon (node 8) gave a talk on “Profession : researcher in particle physics” in front of 50 attendants in November 2007.
- The group at the University of Bern (node 9) organise a series of six lectures on physics called “Physik am Samstag” each year, which is aimed at high-school students who consider studying physics. Two of the six lectures are devoted to particle physics, an experimental one and a theoretical one – the latter, “The broken mirrors”, was given by J. Gasser.

2.4 Media

The start of the LHC has definitely increased the media coverage of particle physics. However, most of its description insists more on the “Big Science” aspects of the LHC projects than on the objectives and originality of this domain of physics. Members of FLAVIANet have helped to promote these aspects of research in particle physics through various initiatives:

- In Germany, a TV programme for popular science, called “Nano” on the 3SAT channel offered some members of nodes 6 and 8 the opportunity to discuss several aspects of FLAVIANet research in the last year, with an interview of Martin Beneke (Aachen) on the asymmetry between matter and antimatter and a report on numerical simulations of lattice QCD performed in Mainz.
- Seminars organised at University of Vienna (node 10) have been broadcast through an education TV channel.
- Several nodes took part in press conferences and media campaigns launched in European countries for the first LHC beam, for instance Valencia (node 1), Helsinki (node 7), Orsay (node 8), Vienna (node 10). In addition, scientists of the FLAVIANet are regularly contacted for interviews or articles for popular science journals, e.g., Franck Close (node 3) recently featured on BBC Radio 4 (UK).
- Members of the FLAVIANet network in Orsay (node 8) have created their own journal, called “Élémentaire”. This journal of 64 pages is published twice a year and is aimed at students interested in discovering nuclear and particle physics.
- In addition to the outreach page of the FLAVIANet website, several nodes have contributed to web pages on particle physics in local languages, for instance Barcelona (node 2), Oslo (node 7), Orsay (node 8), Vienna (node 10). Another interesting initiative has been developed in Helsinki, with have a “blog” kept by young experimentalists at CERN and Helsinki.

2.5 Outreach infrastructures

Some of the nodes have developed specific infrastructures, on which they can rely for their outreach activities:

- The involvement of IFIC (node 1) in Outreach activities enabled to develop a Scientific Outreach Office, which is used in all CSIC institutes in the Valencia Region and which will be extended to other Spanish provinces.
- The IPPP in Durham (node 3) has a Science and Society officer, developing several family shows explaining the science behind the LHC, coordinating the outreach activities towards schools, organising exhibitions linking physics and arts . . .
- Lund (node 7) has a “National resource centre for physics”, which is a national resource organisation to help physics teachers at schools.
- The LAL laboratory (node 8) owns an exhibition room dedicated to particle physics, with a bubble chamber showing tracks of particles from cosmic rays as they go through the detector and a cosmic arch detecting cosmic rays.
- Desy-Zeuthen (node 11) has set up a lab room for high-school students to perform experiments with a visit of about 2500 students per year.

The existence of such dedicated centres, as well as the large variety of outreach activities inside the nodes of the network, shows how lively and significant outreach activities are inside *FLAVIANet*. Let us mention that the contacts established inside the research and training environment of the *FLAVIANet* can also help to improve the outreach skills of the various nodes: ideas and material for exhibitions and conferences can easily be shared between members of the network, in the margin of network meetings conferences or inter-node visits. We plan to propose further joint outreach activities during the next years of the contract, especially school-oriented common events.

3 Conclusions

The *FLAVIANet* network offers a first level training in Flavor Physics, theory and experiments, and all boundary research fields, to all the ESR and ER recruited and to all the *FLAVIANet* young researchers. The network constitutes a very lively, cutting-edge scientific framework offering countless concrete and well structured opportunities to interact with the best European and International experts in this research field. This network is an outstanding reference point for the scientific research in Europe in the Flavor Physics field and for the training of the next generation of scientists. All the complementary aspects of the training have been taken into account and an appropriate career and development path has been established for each researcher. We are fully aware of the importance of training young scientists that can stand out both for their scientific

competence, their unlimited creativity and capability to explore nature, their passion to communicate the wonder and the impact of the human scientific adventure and their mastering of all the societal processes related to science. It is no doubt that *FLAVIANet* is contributing and will contribute in the best way to producing high level scientists maintaining an European leadership in Particle Physics. On the other hand it is important that Europe focuses in continuing to create appropriate opportunities for the next generation of scientists, besides those offered at the level of the network.