Training Activity

CONTRACT NO. 35482

Full Term Report 01/10/2006 — 30/09/2010

We report here on the four years of Training and TOK activities of the *Marie Curie Research and Training Network* FLAVIA*net*. The Training and TOK activities have been organized, supervised and coordinated among the several nodes by the FLAVIA*net* 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 (Technical U. Munich).
In the following we report the training and TOK achievements for each of the eleven FLAVIA*net* nodes in the period 01/10/2006–30/09/2010.
For each one of the Early Stage Researchers (ESR) and each one of the Experienced Researchers (ER) of our network 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 has been 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 Meetings and Annual General European Flavor Physics Schools and several Research Training Workshops (detailed in the FLAVIA*net* Research Report).

Annual General Schools of the network

The Annual European Flavour Physics School of 2007 has been organized at the INFN National Laboratories in Frascati, Italy, as the “XII LNF Spring School in Nuclear, Subnuclear and

Astroparticle Physics" from 14th to 18th of May, 2007. The School has been devoted to the theoretical and experimental developments in Flavour and Hadron physics and lectures have been given by world experts in the subject coming from the network and from outside the network. The main lectures have been:
D. Bryman (Triumph): Rare pi & K decay experiments
P. Franzini (LNF): The Physics of KLOE
K. Lane (Boston): Effective Field Theories for LHC physics
W. Marciano (BNL): The Anomalous Magnetic Moment of the muon
A. Pich (Valencia): Effective Field Theories for low Energy Physics
A. Stocchi (Orsay): Recent developments in Beauty and Charm Physics
A. Vladikas (Rome-2): Flavour Physics on the Lattice
A total of 35 students from all over the world have attended with 18 students (Ph.D. and post-doc) coming from the FLAVIA*net* nodes.

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 FLAVIA*net* 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.

The annual Flavianet school of 2009 took place in Karlsruhe, Germany, from Sep 7 to 18, 2009. This year school put the emphasis on short-distance aspects of flavour physics, such as electroweak decays and rare processes sensitive to new physics. Twelve scientists from Europe and the USA taught 37 hours of lectures, which were complemented by 10 tutorial session devoted to the discussion of the homework assignments. The school was attended by 60 participants, 27 of which were from Karlsruhe, 24 were affiliated with other Flavianet institutions and 9 were enrolled in universities outside Flavianet. Among the 24 external Flavianet participants were 4 current or former Flavianet ESR: Pablo Roig (node 8), Ilaria Jemos (node 7), Miguel Escobedo (node 5) and Pere Masjuan (node 10). As a novel feature, we have included a business partner in the organisation of the school, the company <phi–t>, which is a spin-off from an experimental flavour physics group in Karlsruhe. <phi–t> has financially supported the school and its CEO, Prof. Michael Feindt, has given a lecture on *Artificial intelligence for flavour physics and economy*. Further events of the school were a poster session, at which the participants could present their thesis topics and scientific results to each other, and a guided tour of the experimental facilities at the Karlsruhe Research Center (Northern Campus of the Karlsruhe Institute of Technology). The latter include the KATRIN experiment, devoted to the measurement of the neutrino mass.

The annual Flavianet school of 2010 took place in Bern, Switzerland, from June 21 to July 2, 2010. This year school was mainly aimed at PhD students and postdocs of the network, but was of course open to external participants. The number of students was 43, of which 18 from Bern, and we had 11 lecturers (for details see the report of Node 9). The school was organized as follows: 2 blocks of 2x45 min. lectures separated by a coffee break in the morning and two analogous blocks of exercises in the afternoon. On one afternoon we had a review of recent lattice results. We have been very positively impressed by the commitment of the students, who followed all the lectures and never missed even a single afternoon exercise session (despite the exceptionally good weather we had in Bern during that time). Especially the afternoon sessions were very lively and intensely used by the students to learn as much as possible from the lecturers. It was a decision of the Network to offer in this school a broad view of various aspects of flavour physics, both experimental and theoretical, avoiding going too much in depth into any single subject and the decision turned out to be very appropriate.

Annual General meetings the Annual General Meeting held in Barcelona in November 2006, the Annual General Meeting held in Orsay in November 2007. the Annual General Meeting held at IPPP in Durham in September 2008 , The Annual General meeting held in Bari in November 2009, the final Annual General Meeting held at Technical University in Munich in September 2010 (all detailed in the FLAVIA*net* Research Report),

Inside the FLAVIA*net* the young researchers have access to a lively, cutting-edge scientific frame and to countless and concrete opportunities to interact with the best European ad 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 FLAVIA*net* nodes has been complemented with lectures, courses and seminars given by experts coming from outside the node, secondments of ESR, ER and FLAVIA*net* experts among the nodes as well as complimentary skills and language courses.

1 Training and TOK achievements

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

YEAR 1

1.1.1 OFFERED PH. D. 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 FLAVIA*net* topics are:

- Ph.D. Course on "Theory and Phenomenology of the Strong Interactions", Valencia, November 2006–May 2007
- Ph.D. Course on "Electroweak Interactions", Valencia, November 2006–May 2007
- Ph.D. Course on "Advanced Quantum Field Theory", Valencia, October 2006–January 2007
- Ph.D. Course on "Advanced General Relativity", Valencia, October 2006–January 2007
- Ph.D. Course on "Experimental Nuclear Physics", Valencia, October 2006–January 2007
- Ph.D. Course on "High-Energy Astrophysics", Valencia, October 2006–January 2007
- Ph.D. Course on "Non-perturbative Methods", Valencia, January–May 2007
- Ph.D. Course on "High Energy Physics", Valencia, January–May 2007
- Ph.D. Course on "Advanced Phenomenology", Valencia, January–May 2007
- Ph.D. Course on "Many Body Quantum Field Theory", Valencia, January–May 2007
- Ph.D. Course on "Geometry, Topology and Physics Applications", Valencia, January–May 2007

1.1.2 OFFERED COURSES at ANY LEVEL of interest for the FLAVIANET

- Undergraduate Course on "Quantum Field Theory", Valencia, September 2006–May 2007
- Course on "Quantum Field Theory" for Master students in theoretical physics, given by E. Pallante, Univ. Groningen, 2006-2007
- Postgraduate Course on "The Standard Model", given by A. Pich at the 4th CERN–CLAF School of High-Energy Physics, Viña del Mar, Valparaiso Region, Chile, 18 February 3 March 2007

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

- Course on "Effective Field Theories", given by A. Pich (node 1) at Frascati (node 5), May 2007
- Course on "The Standard Model", given by A. Pich (node 1) at CERN (node 9), July 2007
- 3 Ph.D. students (Paola Ferrario, Martín González Alonso, Pablo Roig Garcés) took part in the *XII LNF Spring School in Nuclear, Subnuclear and Astroparticle Physics* (Frascati, Italy, 14–18 May, 2007). Two talks presented (15/5/07):
  - M. González, "QCD condensates for the light quark V-A correlator".
  - P. Roig, "Hadronic decays of the tau lepton into kaon modes within large Nc QCD".
- Training stay of the Ph.D. student Pablo Roig Garcés at Universitá degli Studi di Milano (node 5), 12 October – 16 December, 2006
- Training stay of the Ph.D. student Pablo Roig Garcés at Universitá di Bari (node 5), 16–23 December, 2006
- Training stay of the Ph.D. student Vicent Mateu at MPI in Munich (node 4), 16 September – 2 December, 2007
- Training stay of the Ph.D. student Emma Torró Pastor at CERN (node 9), October-November 2006

1.1.4 VISIT of SENIOR SCIENTISTS from OUTSIDE the NETWORK

- Olga Mena (Fermilab, USA), 15-30 October 2006
- Stefano Catani (INFN Firenze, Italy), 11-15 December 2006
- Sacha Davidson (CNRS Lyon, France), 5-9 February 2007

- Margarida Rebelo (CFTP Lisbon, Portugal), 19-23 March 2007
- Simon Eidelman (Budker Institute of Nuclear Physics, Novosibirsk, Russia), 16-20 April 2007
- Geraldine Servant (CERN, Switzerland), 1-31 May 2007
- Massimiliano Grazzini (INFN Firenze, Italy), 28 May – 1 June 2007
- Durga Prasad Roy (TIFR Bombay, India), May-December 2007

1.1.5 GENERAL TRAINING

- Ph.D. Course on "Numerical and Statistical Methods", Valencia, October 2006–January 2007
- 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
- "De Sitter Lecture Series in Theoretical Physics", Univ. Groningen (aimed to provide an education at the forefront of theoretical physics for Ph.D students and early stage researchers)

1.1.6 ER HIRED (October 1, 2006 – September 30, 2007)

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

1.1.7 ER PERSONAL CAREER DEVELOPMENT PLAN TUTORING, ADVISING, OPPORTUNITIES

- **David Greynat, ER contract, Valencia**
  David Greynat has started his ER contract 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.

  Career Development Plan
  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. 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. Interactions with local Valencia mathematicians are already planned.

Training and collaboration
At the University of Valencia there exist a very complete programme of postgraduate courses. In addition, IFIC hosts a large number of seminars and colloquiums on many topics. Thus, David Greynat will have a wide choice of options to complement his present physics and mathematics background. Moreover, he will attend the FLAVIA*net* general meetings and some specialized international workshops. IFIC is a large physics institute; therefore, there are many possibilities for collaborative work.

Achievements
The FLAVIA*net* contract of David Greynat has just started. Nevertheless, he is already working in a common project with members of the IFIC node. Some preliminary results related with the K_{l3} form factor calculation have been already obtained.

YEAR 2

1.1.8 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 FLAVIA*net* 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.

1.1.9 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.

1.1.10 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 $\tau \to K\overline{K}\pi\nu_\tau$".
- 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.

1.1.11 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

1.1.12 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 Virotta (node 11)

  Flavianet ER participating: Artyom Hovhannisyan (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-Martńez, Eike Mueller, Hugo Pedroso de Lima, David Wilson (node 3).

  Guido Bell, Andreas Crivellin, Lars Hofer, Artyom Hovhannisyan, 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 Virotta (node 11).

1.1.13 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

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

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

1.1.15 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.

FLAVIA*net* 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 FLAVIA*net* 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.

YEAR 3

1.1.16 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 FLAVIA*net* topics are :

- Ph.D. course on "Quantum Field Theory", Valencia, September – November 2008.
- Ph.D. course on "Advanced Quantum Field Theory", Valencia, November 2008 – January 2009.
- Ph.D. course on "Quantum Chromodynamics", Valencia, November 2008 – January 2009.
- Ph.D. course on "Electroweak interactions", Valencia, November 2008 – January 2009.
- Ph.D. course on "Experimental Nuclear Physics", Valencia, November 2008 – January 2009.
- Ph.D. course on "High Energy Physics", Valencia, January – March 2009.
- Ph.D. course on "Non-perturbative methods", Valencia, January – March 2009.
- Ph.D. course on "Advanced Phenomenology", Valencia, January – March 2009.

1.1.17 OFFERED COURSES at ANY LEVEL of interest for the FLAVIANET

- A. Pich, "Field Theory and the Standard Model"
  International Summer School and Conference on High Energy Physics: Standard Model and Beyond (ISSCSMB'09), Muğla, Akyaka, Turkey, 27 August – 4 September 2009.
- A. Pich, "Chiral Perturbation Theory"
  Flavianet School on Flavour Physics, Universität Karlsruhe, Karlsruhe, Germany, 7–18 September 2009.

- P. Hernández, "Lattice QCD Fundamentals"
  Modern perspectives in lattice QCD: Quantum field theory and high performance computing, Les Houches Summer School, Les Houches, France, 3–28 August 2009.

- P. Hernández, "Neutrino Physics"
  V CERN Latin Americal School of High Energy Physics Recinto Quirama, Colombia, March 2009.

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

- Seminar, Dr. Johan Bijnens (Lund University, node 7), at IFIC (Valencia), October 2008.
- Seminar, Dr. Gregorio Herdoiza (DESY Zeuthen, node 11), at IFIC (Valencia), May 2009.
- Seminar, Dr. Luigi del Debbio (CERN, node 9), at IFIC (Valencia), May 2009.
- Seminar, Dr. Juan J. Sanz Cillero (IFAE Barcelona, node 2), at IFIC (Valencia) June 2009.

1.1.19 VISIT of SENIOR SCIENTISTS from OUTSIDE the NETWORK

- Dr. Francisco V. Flores-Baez, *CINVESTAV*, Mexico, Mexico, to IFIC (Valencia) in December 2008.
- Dr. Juan Rojo, *INFN*, Milan, Italy to IFIC (Valencia) in December 2008.
- Dr. Jan Winter, *Fermi National Laboratory*, USA to IFIC (Valencia) in January 2009.
- Dr. H.Q. Zheng, *Beijing University*, Beijing, China, to IFIC (Valencia) in February 2009.
- Dr. Jan Winter, *Fermi National Laboratory*, USA to IFIC (Valencia) in May 2009.
- Dr. Tanju Gleisberg, *SLAC*, USA to IFIC (Valencia) in May 2009.
- Dr. Sven Heinemeyer, *IFCA*, Santander, Spain to IFIC (Valencia) in May 2009.
- Dr. Andreas Nyffeler, *Harish-Chandra Research Institute*, Allahabad, India, to IFIC (Valencia) in June 2009.

1.1.20 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

1.1.21 ER already selected and committed (their contract will start next year)

- Emilie Passemar
  ER contract starts on 1 October 2009, one–year contract.

1.1.22 ER CAREER DEVELOPMENT PLAN, TUTORING, ADVISING, OPPORTUNITIES

- **Emilie Passemar, ER contract, Valencia**

Emilie Passemar has started her ER contract (12 months) on 1 October 2009. Her local advisor is Antonio Pich. She receives local guidance from several members of the Valencia group (Jorge Portolés, Pilar Hernández, Germán Rodrigo) and from members of other FLAVIA*net* nodes (Gilberto Colangelo, Bern; Sebastien Descotes-Genon, Paris). Complementary training on experimental physics is offered locally by Arantza Oyanguren and Fernando Martínez.

BRIEF OVERVIEW OF RESEARCH PROJECT AND MAJOR ACCOMPLISHMENTS EXPECTED Emilie Passemar got her Ph.D. in Paris (node 8), under the supervision of Jan Stern. Her Ph.D. research was focused to the study of phenomenological signals of non-standard right-handed currents at low energies. She has acquired later a very valuable expertise on low-energy dynamics at Bern (node 9). Her present research work concerns the phenomenological study of the Standard Model dynamics at low energies and the search for possible signals of new physics scenarios. FLAVIA*net* offers her the possibility to interact with experts on these fields and broaden her personal expertise.

LONG-TERM CAREER OBJECTIVES (over 5 years)
1. Goals: Emilie Passemar is heavily involved in the study of semileptonic kaon decays. The K_{l3} and K_{l4} decay modes and the dynamical analysis of the form factors relevant for these processes are one of the major objectives of her work. She will also investigate the related form factors appearing in the hadronic decay modes of the τ lepton. Emilie Passemar has developed powerful dispersive tools which she is now applying to other physical systems such as the $\eta \to 3\pi$ decays. In Valencia Emilie will integrate in a joint effort to improve our dynamical understanding of low-energy processes. This includes several elementary particle systems such as kaon, D and

B mesons and the τ lepton. The main goal of her ER stay at Valencia is the implementation of dispersive techniques in several effective field theory calculations.

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

In addition to the usual quantum field theory framework, the required technical expertise include sophisticated mathematical tools, such as complex analysis, special functions and statistical tools for data analyses. Emilie will profit from the simultaneous presence at IFIC of higher-loop practitioners, a consolidated group with long-term expertise in ChPT techniques and an experimental group involved in flavour physics. The expertise of Emilie Passemar will be very useful for the training of the local PhD students of the Valencia node, which can profit from her very professional advise.

SHORT-TERM OBJECTIVES (1-2 years)

1. Research results/Anticipated publications:

We anticipate a minimum of two publications with relevant results within her 1–year contract. In addition, we expect that she will write several proceedings as a result of her participation at international conferences.

2. Research Skills and techniques:

She is already a very experienced researcher. Nevertheless, she will broaden her knowledge with a dedicated training on effective theories for heavy quark systems and higgsless models of electroweak symmetry breaking.

3. Research management:

We plan to involve Emilie in the organization of some FLAVIA*net* events. She will also participate in the FLAVIA*net* working groups. In addition, Emilie will have the possibility to acquire a basic knowledge of how an European Contract is administered and dealt with, and will get familiar with the relevant information about applications for research grants and postdoctoral fellowships.

4. Communication skills:

The FLAVIA*net* 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. Emilie has already presented results in past EuroFlavour Conferences. Her new achievements will be presented at the next EuroFlavour09 Conference in Bari.

5. Other professional training

At IFIC, Emilie will have the possibility to profit from a very extensive programme of seminars and colloquia in various aspects of particle physics, from cosmology to condensed matter.

1. Anticipated networking opportunities:

FLAVIA*net* will allow Emilie to perform research visits and short stays in several nodes with common interests and keep a very active scientific collaboration with them. We could certainly anticipate a very strong relation with the French and Swiss nodes.

2. Other activities (community, etc) with professional relevance:

Emilie is expected to follow some language courses to learn Spanish.

YEAR 4

1.1.23 OFFERED PH. COURSES (LOCALLY)

- Ph.D. course on "Quantum Field Theory", Valencia, September – November 2009.
- Ph.D. course on "Advanced Quantum Field Theory", Valencia, November 2009 – January 2010.
- Ph.D. course on "Quantum Chromodynamics", Valencia, November 2009 – January 2010.
- Ph.D. course on "Electroweak interactions", Valencia, November 2009 – January 2010.
- Ph.D. course on "Experimental Nuclear Physics", Valencia, November 2009 – January 2010.
- Ph.D. course on "High Energy Physics", Valencia, January – March 2010.
- Ph.D. course on "Non-perturbative methods", Valencia, January – March 2010.
- Ph.D. course on "Advanced Phenomenology", Valencia, January – March 2010.

1.1.24 OFFERED COURSES at ANY LEVEL of interest for the FLAVIANET

- "Field Theory and the Electroweak Standard Model", A. Pich, The 2010 European School of High-Energy Physics, Raseborg, Finland, 20–27 June 2010.
- "The Standard Model", A. Pich, International School on Astroparticle Physics (ISAPP 2010), "Multi-Mesenger Approach to Astroparticle Physics", Zaragoza, Spain, 13–22 July 2010.

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

- "Fundamentals of Lattice Field Theory", P. Hernández, University of Valencia (node 1), Flavianet School on Flavour Physics in Bern (node 9), June 2010.
- "QCD tests from tau decay data", A. Pich, University of Valencia (node 1), Colloquium in Memory of Jan Stern in Paris (node 8), 3 October 2009.
- Seminar, "Modeling the threshold region in $e^+e^- \to \pi^+\pi^-\gamma$ for Radiative Return at DAPHNE", I. Sergiy, University of Silesia (node 6) in Valencia (node 1), November 2009.
- Seminar, "A dispersive treatment of $K_{\ell 4}$ decays", P. Stoffer, University of Bern (node 9) in Valencia (node 1), April 2010.
- Seminar, "B decays beyond leading order", P. Volker, University of Bern (node 9) in Valencia (node 1), July 2010.

1.1.26 VISIT of SENIOR SCIENTISTS from OUTSIDE the NETWORK

- Dr. Daniel Gómez-Dumm, *Universidad Nacional de La Plata, Argentina*, to IFIC (Valencia) in November 2009.
- Prof. Johannes Blümlein, *DESY Zeuthen, Germany*, to IFIC (Valencia) in December 2009.
- Dr. John Junion, *University of California at Davis, USA*, to IFIC (Valencia) in January 2010.
- Dr. Alvert de Roeck, *CERN, Switzerland*, to IFIC (Valencia) in February 2010.
- Dr. Tomaso Dorigo, *INFN Padova, Italy*, to IFIC (Valencia) in April 2010.
- Dr. Vincenzo Cirigliano, *Los Alamos, USA*, to IFIC (Valencia) in June 2010.
- Dr. B. Ananthanarayan, *Center for High Energy Physics, Bangalore, India*, to IFIC (Valencia) in June 2010.
- Dr. Martin Hentschinski, *DESY Hamburg, Germany*, to IFIC (Valencia) in November-December 2009.

1.1.27 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

1.1.28 ER HIRED (October 1, 2009-September 30, 2010)

- Emilie Passemar
  ER contract starts on 1 October 2009, one–year contract.

1.1.29 ER CAREER DEVELOPMENT PLAN, TUTORING, ADVISING, OPPORTUNITIES

- **Emilie Passemar, ER contract, Valencia**

Emilie Passemar started her ER contract (12 months) on 1 October 2009. Her local advisor is Antonio Pich. She has received local guidance from several members of the Valencia group (Jorge Portolés, Pilar Hernández, Germán Rodrigo) and from members of other Flavianet nodes (Gilberto Colangelo, Bern; Sebastien Descotes-Genon, Paris). Complementary training on experimental physics has been offered locally by Arantza Oyanguren and Fernando Martínez.

BRIEF OVERVIEW OF RESEARCH PROJECT AND MAJOR ACCOMPLISHMENTS EXPECTED Emilie Passemar got her Ph.D. in Paris (node 8), under the supervision of Jan Stern. Her Ph.D. research was focused to the study of phenomenological signals of non-standard right-handed currents at low energies. She has acquired later a very valuable expertise on low-energy dynamics at Bern (node 9). Her present research work concerns the phenomenological study of the Standard Model dynamics at low energies and the search for possible signals of new physics scenarios. FLAVIA*net* offers her the possibility to interact with experts on these fields and broaden her personal expertise.

LONG-TERM CAREER OBJECTIVES (over 5 years)

1. Goals: Emilie Passemar is heavily involved in the study of semileptonic kaon decays. The K_{l3} and K_{l4} decay modes and the dynamical analysis of the form factors relevant for these processes are one of the major objectives of her work. She has also investigated the related form factors appearing in the hadronic decay modes of the τ lepton. Emilie Passemar has developed powerful dispersive tools which she is now applying to other physical systems such as the $\eta \to 3\pi$ decays. In Valencia Emilie has integrated in a joint effort to improve our dynamical understanding of low-energy processes. This includes several elementary particle systems such as kaon, D and B mesons and the τ lepton. The main goal of her ER stay at Valencia has been the implementation of dispersive techniques in several effective field theory calculations.

2. What further research activity or other training is needed to attain these goals? In addition to the usual quantum field theory framework, the required technical expertise include sophisticated mathematical tools, such as complex analysis, special functions and statistical tools for data analyses. Emilie has profit from the simultaneous presence at IFIC of higher-loop practitioners, a consolidated group with long-term expertise in ChPT techniques and an experimental group involved in flavour physics. The expertise of Emilie Passemar has been very useful for the training of the local PhD students of the Valencia node, which could profit from her very professional advise.

SHORT-TERM OBJECTIVES (1-2 years)

1. Research results/Anticipated publications:

   During her one-year Flavianet contract in Valencia, Emilie Passemar has published 7 papers at high-level international journals (2 of them correspond to conference proceedings).

2. Research Skills and techniques: She is already a very experienced researcher. Nevertheless, she has broaden her knowledge with a dedicated training on effective theories for heavy meson form factors and tau decays.

3. Research management: She has participated in the FLAVIA*net* working groups. In addition, Emilie has had the possibility to acquire a basic knowledge of how an European Contract is administered and dealt with, and will get familiar with the relevant information about applications for research grants and postdoctoral fellowships.

4. Communication skills: The FLAVIA*net* 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. Emilie has already presented results in past EuroFlavour Conferences. Her achievements have been presented at the EuroFlavour meetings.

5. Other professional training At IFIC, Emilie has had the possibility to profit from a very extensive programme of seminars and colloquia in various aspects of particle physics, from cosmology to condensed matter.

1. Anticipated networking opportunities: FLAVIA*net* has allowed Emilie to perform research visits and short stays in several nodes with common interests and keep a very active scientific collaboration with them. We could certainly anticipate a very strong relation with the French and Swiss nodes.
2. Other activities (community, etc) with professional relevance:

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 1

1.2.1 OFFERED PH.D. COURSES (LOCALLY)

The different universities within the node have had Ph.D. programs for many years. This last year was a transitional period since new Master programs are beginning to develop now in our universities. Examples of courses taught are:

- ”QCD and Renormalization Group Methods” taught by M. Jamin at Univ. Autonoma de Barcelona.

- ”Particle Physics” within the Master ”Astrophysics, Particle Physics and Cosmology” at Univ. de Barcelona and ”Supercomputation and Parallel Programming” within the Master ”Applied and Computational Physics ” joint Master at Univ. of Barcelona and Univ. Politecnica de Catalunya, taught by Ricardo Graciani.

- ”The Standard Model and its Phenomenology” within the Master ”Physics” at Univ. de Granada, taught by F. Cornet and J. Prades.

- ”Renormalization Group and Critical Phenomena” within the Master ”Astrophysics, Particle Physics and Cosmology” at Univ. de Barcelona, taught by D. Espriu.

- ”Standard Model” within the Master ”Astrophysics, Particle Physics and Cosmology” at Univ. de Barcelona, taught by J. Soto.

- ”Nuclear Physics at Intermediate Energies” within the program ”Nuclear Physics” taught at the Univ. de Salamanca by J. Nieves and A. Ramos.

- ”QCD-based Hadronic Physics” within the program ”Advanced Methods and Techniques in Physics”, taught by J. Nieves.

1.2.2 OFFERED COURSES at ANY LEVEL of interest for the FLAVIANET

- Course on ”Phenomenology of QCD”, delivered by M. Jamin, Spanish School of High Energy Physics, Jaca, Spain, March 6-18 2007.

1.2.3 ESR HIRED (October1, 2006.September 30, 2007)

- There was an ESR position selection process in which Ying Li was chosen. Although he initially agreed to come, he changed his mind at the last moment. The position will be offered again this year.

YEAR 2

1.2.4 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: $\mathrm{http://www.ugr.es/mtaf/Informacion-EN.htm}$
- Master at UAB: $\mathrm{http://bioinf3.uab.cat/masterfisica/}$

1.2.5 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

1.2.6 ESR HIRED

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

1.2.7 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 the 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 ojectives (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.

YEAR 3

1.2.8 OFFERED PH. COURSES (LOCALLY)

- Matthias Jamin: Advanced Quantum Field Theory @ UAB, Barcelona, Spain, October 2008 - February 2009.
- Rafael Escribano: Particle Physics, UAB,Oct 2008 — Feb 2009.
- Joaquim Prades and Fernando Cornet: Master Course, “Phenomenology of the Standard Model”, Granada Univ. Oct 2008 — March 2009.

1.2.9 OFFERED COURSES at ANY LEVEL of interest for the FLAVIANET

- J. Prades: Undergraduate Course on “Elementary Particle Physics”, Granada Univ., February 2009 - June 2009

1.2.10 ORGANIZED SCHOOLS

- J. Soto: Flavianet-School Karlsruhe 2009, Karlsruhe, September 7-18, 2009 6 hour course: Effective field theories for heavy quarks

1.2.11 GENERAL TRAINING

- "Second Meeting on e-science in Andalusia (e-CA)" Granada, 16-17 October 2008, Local organizers, F. Cornet and J. Prades

1.2.12 ESR HIRED (October 1, 2008.September 30, 2009)

- Zhi-Hui Guo started a one year ESR at Universitat Autonoma de Barcelona to complete his second ESR year at Universidad de Granada, as an agreement to share this ESR position between these two universities within node 2.

- Maximilian Stahlhofen has used 6 months at Univ. Autonoma de Barcelona.

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

- Clark Downum

1.2.14 ESR PERSONAL CAREER DEVELOPMENT PLAN TUTORING, ADVISING, OPPORTUNITIES

- Name: Zhi-Hui Guo

- Workplace:
  Grup de Física Teórica and IFAE, Universitat Autónoma de Barcelona, E-08193 Barcelona (Spain);
  CAFPE and Departamento de Física Teórica y del Cosmos, Universidad de Granada, Campus de Fuente Nueva, E-18002 Granada (Spain)

- Name of the supervisors: Joaquim Prades, Juan José Sanz Cillero

BRIEF OVERVIEW OF RESEARCH PROJECT AND MAJOR ACCOMPLISHMENTS EXPECTED In the low-energy regime, the perturbative Quantum Chromodynamics (QCD) breaks down. However, in the massless limit, the chiral invariant (u, d, s) light-quark interaction becomes spontaneously broken, generating a set of (pseudo) Goldstone bosons which can be identified with the lightest multiplet of pseudoscalar mesons. Their dynamics can be then described at soft momentum and small quark masses by means of an effective field theory (EFT) based on chiral symmetry, chiral perturbation theory (χPT).
This EFT stops being valid when the energy reaches the first resonances. One needs then to employ alternative methods for the description of the observables (e.g. the $\pi\pi$–scattering) in

this range, like, for instance, unitarization methods, resonance lagrangians... Nevertheless, it is important that the extended description still recovers the right long-distance limit prescribed by χPT.

In the present era of high-precision measurements, it is becoming crucial to have better and better determinations of the standard model parameters. Eventually, this may allow the observation of new physics in observables such as the muon anomalous magnetic moment or $K_{\ell 3}$ decays, where a sizable part of the uncertainties have hadronic origin.

In a first stage of the project, the fellow plans to apply the various chiral descriptions for strong interactions to processes which are already pretty well under control both from the experimental and theoretical side. This, in addition to increase the precision of currently known parameters, will allow to refine the description of resonance and chiral Goldstone interactions. In a second step of the project, this will be applied to the search of small deviations from the standard model, once the theoretical hadronical uncertainties have been reduced to a marginal level.

Likewise, in parallel to his work in QCD, the fellow is carrying on a project on physics beyond the standard model. In collaboration with researchers from other groups, the fellow is studying some aspects of several Randall-Sundrum scenarios that could show up in the forthcoming LHC experiment.

In his stay at Granada Univ., the fellow will work on two long term projects which will improve his knowledge and skillness on non-perturbative QCD. The first one is a complete study of the scalar form factor of the three light quarks (u, d and s) within an unitarized non-perturbative chiral approach. This study will be done in the combined limits of the light quarks masses going to zero and large number of QCD colors (N_c). The applications of this study are several: computation of light quark masses, scalar matrix elements, computation of p^4 χPT couplings among others. The second project the fellow will develop in his stay at Granada is the calculation of the lowest order coupling constants describing the rare kaon decays $K \to \pi e^+ e^-$ at next-to-leading in a $1/N_c$ expansion. These rare kaon decays are quite important for elucidating the type of new physics beyond the Standard Model. They are complementary studies to direct searches that will be performed at LHC shortly.

LONG-TERM CAREER OBJECTIVES (over 5 years)

1. Goals: During his Ph.D. the fellow studied the essential effective field theory and quantum field theory techniques, and their applications to the description of the hadronic interaction in the non-perturbative (low-energy) range of QCD. Thus, nowadays, new accurate and precise determinations of the standard model parameters are leading to very stringent tests on possible new physics.

Many of these techniques will be likely needed if LHC finds new states or strongly interacting regimes at high energies. The fellow, then, plans in the long term to progressively focus his attention in topics beyond the standard model like, for instance, extra dimensions.

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

In order to achieve his goals, it is essential that the fellow collaborates with experts in those fields and attends conferences and workshops related to the topics of his interest.

SHORT-TERM OBJECTIVES (1-2 years)

1. Research results/Anticipated publications: The fellow plans to publish an average of two or three papers per year.

2. Research Skills and techniques:

They will continue to improve through everyday's research work and collaboration with more senior members.

3. Research management:

None.

4. Communication skills:

The communication skills will be improved through presentations of his work within the U.A. Barcelona and U. of Granada, as well as in other institutions. In additional to his individual research, the fellow will collaborate with different research teams of various institutions.

5. Other professional training

The fellow attends the seminars at the U.A. barcelona and U. of Granada on a wide range of topics within the area of particle physics.

1. Anticipated networking opportunities: Flavianet conferences, talks at internal seminars, invited seminar talks at other universities and other conferences and workshops concerned with chiral dynamics, effective theories and flavour physics. The fellow will participate at the yearly Euroflavour network meetings, the next of which will take place at Bari on Novemeber 2009. In addition, the fellow will extend his network through collaborations with other scientists in FlaviaNet. The fellow is also currently applying for postdoctoral positions in U. of Granada in order to extend the collaboration after the ending of the present Early Stage Research period.

2. Other activities (community, etc) with professional relevance: The fellow will attend Spanish language courses.

1.2.15 ESR PERSONAL CAREER DEVELOPMENT PLAN TUTORING, ADVISING, OPPORTUNITIES

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

BRIEF OVERVIEW OF RESEARCH PROJECT AND MAJOR ACCOMPLISHMENTS EXPECTED Recently experimental studies of e^+e^- collisions at energies of $\approx$ 4-4.5 GeV have indicated a variety of states which are not expected from the traditional quark model. There are numerous competing models of these states, including a molecular model where each new state is a bound molecule of two known mesons. Studies of molecular models suggest that they

can describe these newly discovered anomalous states. However, they are very sensitive to poorly determined or arbitrary parameters. This research project seeks to use the results of Lattice QCD to constrain the parameters of molecular models. Using the lattice, it may be possible to constrain the parameters of the molecular models well enough to discriminate between them and other models of these anomalous states. These results would also have broader implications for using Lattice QCD as input for the strong hadron-hadron interaction. The fellow expects to conduct research in collaboration with colleagues at UB. The research will be prepared, with the assistance of collaborators, for publication in peer-reviewed journals. Additionally, talks at conferences or seminar presentations on the results of this work are anticipated.

LONG-TERM CAREER OBJECTIVES (over 5 years)

1. Goals:

To attain maturity as a scientist in the field of Particle Physics.

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

The fellow will give talks at major international conferences as well as seminar presentations at both the home institution and other research institutions.

SHORT-TERM OBJECTIVES (1-2 years)

1. Research results/Anticipated publications: The fellow plans to publish two papers per year.

2. Research Skills and techniques:

They will continue to improve through everyday's research work and collaboration with more senior members.

3. Research management:

None.

4. Communication skills:

Communications skills will be improved through talks within the UB as well as at other institutions and the preparation of papers for publication.

5. Other professional training

The fellow attends the seminars at the UB on a range of subjects within physics and the presentations of other physicists at conferences.

1. Anticipated networking opportunities: The fellow will participate at the yearly Euroflavour network meetings. A brief visit to Jefferson Lab in the United States has been arranged.

2. Other activities (community, etc) with professional relevance: The fellow will act as a peer-reviewer for professional journals.

1.2.16 ESR PERSONAL CAREER DEVELOPMENT PLAN TUTORING, ADVISING, OPPORTUNITIES

- Name: Maximilian Stahlhofen

- Workplace: Universitat Autónoma de Barcelona, Institut de Física d'Altes Energies (IFAE), Barcelona (Spain).
- Name of Supervisor: Prof. Antonio Pineda

BRIEF OVERVIEW OF RESEARCH PROJECT AND MAJOR ACCOMPLISHMENTS EXPECTED The effective field theory vNRQCD allows to describe among others the production of top-antitop pairs in electron-positron collisions at threshold, i.e. with very small relative velocity $v \ll 1$ of the quarks. Potentially large logarithms $\propto \ln v$ are systematically summed up and lead to a scale dependence of the Wilson coefficients of the theory.
The missing contributions to the cross section $\sigma(e^+e^- \to t\,\bar{t})$ in the resonance region at NNLL level are the so-called mixing contributions to the NNLL anomalous dimension of the S-wave production/annihilation current of the topquark pair. To calculate these one has to know the NLL renormalization group running of so-called potentials (4-quark operators). The dominant contributions to the anomalous dimension of these potentials come from vNRQCD diagrams with ultrasoft gluon loops.
In his PhD thesis, which the fellow completed by the end of December 2008, he derived the complete ultrasoft NLL running of the relevant potentials. For that purpose the UV divergent parts of about 10^4 two-loop diagrams were determined. Technical and conceptional issues were discussed. He analysed his (preliminary) results with regard to the consequences for the mentioned cross section and its theoretical uncertainty.
However some open questions related to the non-Abelian two-loop diagrams arose in his work. It is one intent during his fellowship to further address and clarify these issues e.g. by considering a corresponding calculation in an alternative framework, the effective theory pNRQCD, and thus improve the reliability of the prediction for $\sigma(e^+e^- \to t\,\bar{t})$.
Another project will be the determination of the QCD static quark-antiquark potential in 2+1 spacetime dimensions. This will include an analysis up to (partly) NNNLL order of the color singlet as well as the octet channel using the adequate effective theories pNRQCD and vNRQCD. The motivation of which is the application of the results in thermal QCD and a comparison with existing lattice data to gain insights into the nature of the non-perturbative effects (confinement) in the potential, as well as to study the renormalons of the 3+1 dimensional potential, that appear in 2+1 dimensions as logarithmic divergences.
As a first step the fellow will concentrate on the study of the singlet static potential in pNRQCD, since an important part of the calculation has already been performed by members of the institute.

LONG-TERM CAREER OBJECTIVES (over 5 years)

1. Goals:

The PhD work of the fellow was concerned with the theoretical prediction of the cross section $\sigma(e^+e^- \to t\,\bar{t})$ focusing on the contributions from the (ultrasoft) renormalization group running of the quark-antiquark potentials and including a two-loop calculation of the latter. One long-term goal is to pursue this line of research and use his results also in other calculations as e.g. the bottom quark mass determination from non-relativistic Υ sum rules.
Another aim is to extend his expertise to other frameworks to describe the non-relativistic regime

of heavy quark systems, in particular pNRQCD, in order to reveal the relations on the level of specific calculations between the different theories in detail. This might help to find a framework which combines the advantages and reduces the technical and conceptual deficiencies of both approaches to a minimum. The study of the QCD static potential in pNRQCD as well as in vNRQCD, as mentioned above, will be one project in that context.
More generally the fellow aims to gain more understanding of the non-perturbative effects in heavy quark systems with the help of effective field theories of the strong interactions as well as to use his experience in multi-loop calculations, in particular renormalization, in high-energy collider physics.

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

SHORT-TERM OBJECTIVES (1-2 years)
1. Research results/Anticipated publications: The fellow plans to publish one-two papers per year.

2. Research Skills and techniques:
To improve on maturity and independence in research.
3. Research management:
No management duties.
4. Communication skills:
The communications skills will be improved through talks within the IFAE as well as at other institutions.

5. Other professional training
The fellow attends the seminars at the IFAE on a range of subjects within physics.

1. Anticipated networking opportunities: The fellow will participate at the yearly Euroflavour network meetings, the next of which will take place in Bari in November 2009. In addition, the fellow will extend his network through collaborations with other scientists in the network.

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

YEAR 4

1.2.17 OFFERED PH. COURSES (LOCALLY)

- A. Pineda, “Introduction to Quantum Field Theory”, within the Master in High Energy Physics, Astrophysics and Cosmology, (UAB).

- R. Escribano and S. Peris, “Fundamentals of the Standard Model”, within the Master in High Energy Physics, Astrophysics and Cosmology, (UAB).

- M. Jamin , J. Matias and J. Sanz-Cillero, “Advanced Quantum Field Theory”, within the Master in High Energy Physics, Astrophysics and Cosmology, (UAB).

1.2.18 OFFERED COURSES at ANY LEVEL of interest for the FLAVIANET

- A. Ramos, “Weak decays of hypernuclei - theory”, lectures given at the XXIInd Indian-Summer School and SPHERE School on Strangeness Nuclear Physics (SNP2010), Rez/Prague (Czech Republic), September 7-11, 2010.

1.2.19 ESR HIRED (October1, 2009 -September 30, 2010)

- Clark Downum, based at the Univ. of Barcelona.

1.2.20 ER CAREER DEVELOPMENT PLAN, TUTORING, ADVISING, OPPORTUNITIES

- Name of fellow: Clark Downum

- Workplace: Universitat de Barcelona, Dept. d’Estructura i Constituents de la Materia, Barcelona (Spain).

- Name of Supervisor: Prof. Joan Soto

BRIEF OVERVIEW OF RESEARCH PROJECT AND MAJOR ACCOMPLISHMENTS EXPECTED Since the discovery of X(3872) in 2003 by Belle a large number of charmonium-like states have been discovered, which do not match quark model expectations. It is widely believed that the interacion of these states with D-meson pairs is important to understand their dynamics. However little is known at this respect from QCD. We plan to exploit available lattice data on the so called string-breaking in order to get the coupling of heavy quarkonium states to heavy-light meson pairs. We expect to obtain all relevant coupling constants at leading order in the invers heavy quark mass expansion.

LONG-TERM CAREER OBJECTIVES (over 5 years) During his PhD the fellow developed sophysticated codes to study the nucleon-nucleon interaction. His expertese in these techniques will be instrumental for developing anlogous codes to study the interaction of heavy quarkonium with heavy-light meson pairs, as well as to encode in them relevant lattice data. The basic goal is that he keeps developing useful codes at the same time that he learns about these interesting physical states. 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 one paper during the 7 months of the contract.

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 in meetings related to Flavianet, like the Quark Confinement conference that will take place in Madrid in September 2010. In addition, the fellow will extend his network activity 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 1-2

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 FLAVIA*net*. Those offered in Durham and Southampton are:

- Ph.D Course on “Overview of Particle Physics”, Durham, October-May 06/07 & 07/08
- Ph.D Course on “Introductory Field Theory”, Durham, October-May 06/07 & 07/08
- Ph.D Course on “Group Theory”, Durham, October-May 06/07 & 07/08
- Ph.D Course on “Symmetries”, Southampton, October-May 06/07 & 07/08
- Ph.D Course on “Standard Model”, Durham, October-May 06/07 & 07/08
- Ph.D Course on “Standard Model”, Southampton, October-May 06/07 & 07/08
- Ph.D Course on “General Relativity”, Durham, October-May 06/07 & 07/08
- Ph.D Course on “Quantum Electrodynamics”, Durham, October-May 06/07 & 07/08
- Ph.D Course on “Quantum Field Theory”, Durham, October-May 06/07 & 07/08

- Ph.D Course on “Quantum Field Theory”, Southampton, October-May 06/07 & 07/08
- Ph.D Course on “Conformal Field Theory”, Durham, October-May 06/07 & 07/08
- Ph.D Course on “Conformal Field Theory”, Southampton, October-May 06/07 & 07/08
- Ph.D Course on “Lattice Field Theory”, Southampton, October-May 06/07 & 07/08
- Ph.D Course on “Supersymmetry”, Durham, October-May 06/07 & 07/08
- Ph.D Course on “Supersymmetry”, Southampton, October-May 06/07 & 07/08
- Ph.D Course on “Anomalies”, Durham, October-May 06/07 & 07/08
- Ph.D Course on “Strong Interaction Physics”, Durham, October-May 06/07 & 07/08
- Ph.D Course on “Cosmology”, Durham, October-May 06/07 & 07/08
- Ph.D Course on “Cosmology”, Southampton, October-May 06/07 & 07/08
- Ph.D Course on “Superstrings and D-Branes”, Durham, October-May 06/07 & 07/08
- Ph.D Course on “Strings and Brane Theory”, Southampton, October-May 06/07 & 07/08
- Ph.D Course on “Non-perturbative Physics”, Durham, October-May 06/07 & 07/08
- Ph.D Course on “Euclidean Field Theory”, Durham, October-May 06/07 & 07/08
- Ph.D Course on “Effective Field Theory”, Durham, October-May 06/07 & 07/08
- Ph.D Course on “Particle Phenomenology”, Southampton, October-May 06/07 & 07/08
- Ph.D Course on “Flavour Physics and Neutrinos”, Durham, October-May 06/07 & 07/08
- Ph.D Course on “Integrability in Quantum Theory”, Durham, October-May 06/07 & 07/08
- Ph.D Course on “Introduction to AdS/CFT”, Durham, October-May 06/07 & 07/08
- Ph.D Course on “Extra dimensions in gravity”, Durham, October-May 06/07 & 07/08
- Ph.D Course on “Computing for Physicists”, Durham, October-May 06/07 & 07/08
- Ph.D Course on “MHV-rules, recursion relations and unitarity”, Durham, October-May 06/07 & 07/08
- Ph.D Course on “Experimental techniques”, Durham, October-May 06/07 & 07/08
- Ph.D Course on “Simulations in high energy physics”, Durham, October-May 06/07 & 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) participated in *XII LNF Spring School in Nuclear, Subnuclear and Astroparticle Physics*, INFN, Frascati, Italy 14-18 May 2007.
- 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*, Willliamsburg, 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 *Lattice Practices 2006*, Zeuthen, November 2006
- M. Donnellan (PhD student, Southampton) participated in *INT Summer School on Lattice QCD and its Applications*, Seattle, August 2007,

- 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 VISIT of SENIOR SCIENTISTS from OUTSIDE the NETWORK

- Vladimir Braun (Regensburg, Germany) visit to Durham 15/8/07-15/10/07

1.3.4 ORGANIZED SCHOOLS

YETI2007 (Young Theorists and Experimentalists Institute), IPPP, Durham 8-10 January 2007

Flavianet Members participating: Nigel Glover (3), Sam Harper (3), Stuart Ingleby (3), Katherine Korcsak-Gorso (3), Christopher Orme (3)

Participation of others (numbers of Ph.D. students 45, number of postdocs 5, number of scientists 5) Coming from:

1.3.5 GENERAL TRAINING

- Theoretical particle physics seminars in Durham, Oxford and Southampton, several times per week. Postdoctoral reseachers 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.

YEAR 3

1.3.6 COURSES

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

- Ph.D Course on “Overview of Particle Physics”, Durham, October-May 08/09

- Ph.D Course on “Introductory Field Theory”, Durham, October-May 08/09

- Ph.D Course on “Group Theory”, Durham, October-May 08/09
- Ph.D Course on “Symmetries”, Southampton, October-May 08/09
- Ph.D Course on “Standard Model”, Durham, October-May 08/09
- Ph.D Course on “Standard Model”, Southampton, October-May 08/09
- Ph.D Course on “General Relativity”, Durham, October-May 08/09
- Ph.D Course on “Quantum Electrodynamics”, Durham, October-May 08/09
- Ph.D Course on “Quantum Field Theory”, Durham, October-May 08/09
- Ph.D Course on “Quantum Field Theory”, Southampton, October-May 08/09
- Ph.D Course on “Conformal Field Theory”, Durham, October-May 08/09
- Ph.D Course on “Conformal Field Theory”, Southampton, October-May 08/09
- Ph.D Course on “Lattice Field Theory”, Southampton, October-May 08/09
- Ph.D Course on “Supersymmetry”, Durham, October-May 08/09
- Ph.D Course on “Supersymmetry”, Southampton, October-May 08/09
- Ph.D Course on “Anomalies”, Durham, October-May 08/09
- Ph.D Course on “Strong Interaction Physics”, Durham, October-May 08/09
- Ph.D Course on “Cosmology”, Durham, October-May 08/09
- Ph.D Course on “Cosmology”, Southampton, October-May 08/09
- Ph.D Course on “Superstrings and D-Branes”, Durham, October-May 08/09
- Ph.D Course on “Strings and Brane Theory”, Southampton, October-May 08/09
- Ph.D Course on “Non-perturbative Physics”, Durham, October-May 08/09
- Ph.D Course on “Euclidean Field Theory”, Durham, October-May 08/09
- Ph.D Course on “Effective Field Theory and Flavour Physics”, Durham, October-May 08/09
- Ph.D Course on “Particle Phenomenology”, Southampton, October-May 08/09
- Ph.D Course on “Neutrinos and Astroparticle Physics”, Durham, October-May 08/09
- Ph.D Course on “Integrability in Quantum Theory”, Durham, October-May 08/09

- Ph.D Course on “Introduction to AdS/CFT”, Durham, October-May 08/09
- Ph.D Course on “Extra dimensions in gravity”, Durham, October-May 08/09
- Ph.D Course on “Computing for Physicists”, Durham, October-May 08/09
- Ph.D Course on “MHV-rules, recursion relations and unitarity”, Durham, October-May 08/09
- Ph.D Course on “Experimental techniques”, Durham, October-May 08/09
- Ph.D Course on “Simulations in high energy physics”, Durham, October-May 06/07 & 07/08

Similar courses are offered in Oxford, where all first year postgraduate students similarly receive 2 - 3 hours of 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).

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

- A. Bharucha (PhD student, Durham) visited *Andrzej Buras group T31* of Technical University, Munich, Germany, 1st February-31st March 2009
- E. Goode (PhD Student, Southampton) attended the *Hacklatt 2009* workshop for lattice QCD scientists, Edinburgh, Scotland, May 5-7th 2009.
- T. Rae (PhD Student, Southampton) attended the *Flavianet School on Flavour Physics*, Karlsruhe, Germany, September 7-18, 2009.
- J.J. Cobos-Martinez (PhD student, Durham) participated in the International Workshop on *N*on-perturbative aspects of Field Theory, March 30-April 3, 2009. Morelia, Mexico
- P. Fritzsch (PhD student, Münster: ESR, Southampton) participated in *M*odern perspectives in lattice QCD: Quantum field theory and high performance computing, Les Houches, France 3-28 August, 2009.

1.3.8 ORGANIZED SCHOOLS

- Euroflavour 08, Durham, 22-26 September 2008 (64 participants, all from Flavianet)

  Annual UK Particle Theory Meeting, Durham, 18-20 December 2008 (250 participants)

  YETI2009 (Young Theorists and Experimentalists Institute), *r*ediscovering the standard model and prospects for early discovery at the LHC IPPP, Durham 12-14 January 2009

Higgs-Maxwell Meeting, Edinburgh, 4 February 2009

London Workshop on Standard Model discoveries with early LHC data, UCL London, 30 March-1 April 2009 (74 partcipants, inc. 5 INFN, 2 Paris)

Workshop on New Physics with SuperB, Warwick 14-17 April 2009 (70 participants, inc. 22 INFN)

Flavour physics in the era of precision neutrino experiments, Abingdon, 9-11 June 2009 (57 participants, inc. 1 INFN, 2 Valencia, 1 Paris)

65th Scottish Universities Summer School on LHC Physics, St Andrews,¡ 17-14 August 2009 (75 participants, inc. 7 INFN) *B*-physics lectures by G. Isidori (INFN)

1.3.9 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.

1.3.10 ESR HIRED (October 1, 2008-September 30, 2009)

- Patrick Frtizsch, hired in Southampton, 24 month contract

- Stefano Nicotri, hired in Durham, 12 month contract

1.3.11 ESR PERSONAL CAREER DEVELOPMENT PLAN TUTORING, ADVISING, OPPORTUNITIES

- **Patrick Fritzsch, ESR contract, Southampton**

  Patrick Fritzsch began his ESR contract (24 months) on 1 October 2008. His local advisors are Jonathan Flynn and Christopher Sachrajda. He also received guidance from several members of other FLAVIA*net* nodes (Jochen Heitger, Münster; Rainer Sommer, Zeuthen).

  Training, research project and major accomplishments

  Right after participating in the Mid-Term Review of FLAVIA*net* at Durham University in 2008, Patrick Fritzsch moved from Münster (node Germany-North) to his new position at the University of Southampton (UK node). While continuing his former work on a non-perturbative treatment of Heavy Quark Effective Theory (HQET), he started his training in Southampton on non-perturbative renormalization in the MOM scheme, the use of chiral perturbation theory in lattice QCD applications and an introduction to the domain wall fermion (DWF) discretization. 2+1 dynamical fermion configurations of the latter are used by the local group as member of the RBC/UKQCD collaboration to compute, for

instance, the B_K parameter and to study decays like $K \to \pi \ell \nu$, which are relevant for a precision extraction of certain parameters of the CKM matrix. Within this collaboration Patrick Fritzsch also acquired detailed knowledge about the Relativistic Heavy Quark action (RHQ) as developed by Norman Christ (Columbia University, USA) and about CPS, the Columbia Physics System, to compute appropriate matrix elements involving heavy quarks on the lattice.

Patrick Fritzsch participates in several local seminars organized by the Southampton High Energy Physics theory group, which allows him to broaden his view onto current research topics ranging from particle physics phenomenology and collider physics to physics beyond the standard model. In the course of those seminars he introduced his former and current research to other members of the group.

As part of his training he attended the Summer School *Modern perspectives in lattice QCD: Quantum field theory and high performance computing* which took place on August 3?-28, 2009 in Les Houches, France. This international summer school was co-organized by FLAVIA*net*.

Patrick Fritzsch has worked towards the completion of his Ph.D. thesis at the University of Münster. To this end he visited the node Germany-North several times and carried out the quark mass dependence of certain heavy-light meson observables in small-volume two-flavour QCD in the Schrödinger functional framework (SF). This is part of the fully non-perturbative matching strategy of QCD and HQET, developed by the node Germany-North.

Short-term objectives

Patrick Fritzsch will make use of his first year training to compute heavy-light meson observables in the framework of the RHQ action on top of currently produced DWF configurations with its improved chiral properties. The program he wrote using CPS is quite advanced and measurements can be started as soon as the new cluster in Southampton is operational (October 2009). One of the first goals is to compute phenomenologically important couplings like $g_{B^*B\pi}$, which appear in heavy meson chiral lagrangians. Other application as well as joining other projects in Southampton are currently being discussed. Furthermore, Patrick Fritzsch will soon publish results of his thesis and continue his work on HQET, especially carrying out the remaining production and measurement runs of mass-degenerated two-flavour QCD simulations in the SF. First results of this collaborative effort are expected at the beginning of next year.

Long-term career objectives (next 5 years)

Patrick Fritzsch also wants to work in the future on heavy quark phenomenology, especially using non-perturbative methods like the lattice discretization. He profits from the expertise offered by various experts of different FLAVIA*net* nodes. It allows him to work in various sub-collaborations applying different tools to reach this goal. A possible application of the acquired methods during his FLAVIA*net* position is the combination of the SF and DWF for instance. He wants to deepen his current research with those experts as well as starting

new collaborative efforts on topics in high energy physics with other researchers of the field, especially some he met at the summer school in Les Houches.

- **Stefano Nicotri, ESR contract, Durham**

  Stefano Nicotri started his ESR contract (12 months) on November 1^{st} 2008. His local advisor is Michael Pennington.

  Brief overview of activities

  Stefano Nicotri has spent the final part of his PhD at the Institute for Particle Physics Phenomenology, Durham University, completing his thesis and preparing the final exam. The title has been awarded at his home institution in Bari, Italy. In addition, to his research he has prepared to undergo an examination by INFN (*Istituto Nazionale di Fisica Nucleare*, the Italian National Institute for Nuclear and Subnuclear Physics). The exam was passed successfully and he has been declared qualified to eventually get a temporary researcher position (R5) at INFN.

  The research work of Stefano Nicotri concerns the holographic approach to QCD. It is a recently developed analytical approach to the strong coupling regime of the theory of strong interactions. In particular, he has studied the properties of scalar mesons and scalar glueballs in the phenomenological frameworks known as Soft-Wall model and Hard-Wall model, focusing his attention on two-point correlation functions and spectral densities. He has developed a mixed analytical-numerical approach to evaluate the behaviour of hadron masses and widths in a hot medium within the above mentioned models, and consequently to study the phenomenon of dissociation, and its relation with the deconfinement phase transition (and chiral symmetry restoration).

  He has had the opportunity to join a tutoring programme in physics in Durham University, as part of the training, to improve his teaching skills. He has been a tutor for the whole academic year for two groups of eight first-year undergraduate students of the Level 1 Foundation Of Physics course. In addition, he has attended conferences in which he has presented his results as a speaker.

  Long-term career objectives

  During the period covered by his ESR Fellowship, Stefano Nicotri has developed expertise in the field of theoretical particle physics, as well as in teaching and research organization, that he will need in his career. In particular, he has improved his knowledge of quantum field theory, effective field theories, particle phenomenology and computer programming.

  He has had the opportunity to apply for a one-year Research Associate position within the Institute for Particle Physics Phenomenology of Durham University. The application has been successful and he will spend the next year at the Institute, at the end of his ESR contract. Then, he plans to continue his academic career, obtaining a postdoctoral

position from another European research institute, possibly in Italy, though he is open to new experiences in some non-academic environments.

Short-term objectives

Stefano has produced the three scientific papers describing his results. His short-term research goals are the study of chiral symmetry breaking and axial mesons, the study of the $U(1)_A$ problem and the investigation of the properties of Wilson loops and heavy-quark potentials in holographic models of QCD.

YEAR 4

1.3.12 OFFERED PH.D COURSES (LOCALLY)

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

- Ph.D Course on "Overview of Particle Physics", Durham, October 2009-May 2010
- Ph.D Course on "Introductory Field Theory", Durham, October 2009-May 2010
- Ph.D Course on "Group Theory", Durham, October 2009-May 2010
- Ph.D Course on "Symmetries", Southampton, October 2009-May 2010
- Ph.D Course on "Standard Model", Durham, October 2009-May 2010
- Ph.D Course on "Standard Model", Southampton, October 2009-May 2010
- Ph.D Course on "General Relativity", Durham, October 2009-May 2010
- Ph.D Course on "Quantum Electrodynamics", Durham, October 2009-May 2010
- Ph.D Course on "Quantum Field Theory", Durham, October 2009-May 2010
- Ph.D Course on "Quantum Field Theory", Southampton, October 2009-May 2010
- Ph.D Course on "Conformal Field Theory", Durham, October 2009-May 2010
- Ph.D Course on "Conformal Field Theory", Southampton, October 2009-May 2010
- Ph.D Course on "Lattice Field Theory", Southampton, October 2009-May 2010
- Ph.D Course on "Supersymmetry", Durham, October 2009-May 2010
- Ph.D Course on "Supersymmetry", Southampton, October 2009-May 2010
- Ph.D Course on "Anomalies", Durham, October 2009-May 2010

- Ph.D Course on “Strong Interaction Physics”, Durham, October 2009-May 2010
- Ph.D Course on “Cosmology”, Durham, October 2009-May 2010
- Ph.D Course on “Cosmology”, Southampton, October 2009-May 2010
- Ph.D Course on “Superstrings and D-Branes”, Durham, October 2009-May 2010
- Ph.D Course on “Strings and Brane Theory”, Southampton, October 2009-May 2010
- Ph.D Course on “Non-perturbative Physics”, Durham, October 2009-May 2010
- Ph.D Course on “Euclidean Field Theory”, Durham, October 2009-May 2010
- Ph.D Course on “Effective Field Theory and Flavour Physics”, Durham, October 2009-May 2010
- Ph.D Course on “Particle Phenomenology”, Southampton, October 2009-May 2010
- Ph.D Course on “Neutrinos and Astroparticle Physics”, Durham, October 2009-May 2010
- Ph.D Course on “Integrability in Quantum Theory”, Durham, October 2009-May 2010
- Ph.D Course on “Introduction to AdS/CFT”, Durham, October 2009-May 2010
- Ph.D Course on “Extra dimensions in gravity”, Durham, October 2009-May 2010
- Ph.D Course on “Computing for Physicists”, Durham, October 2009-May 2010
- Ph.D Course on “MHV-rules, recursion relations and unitarity”, Durham, October 2009-May 2010
- Ph.D Course on “Experimental techniques”, Durham, October 2009-May 2010
- Ph.D Course on “Simulations in high energy physics”, Durham, October 2009-May 2010

Similar courses are offered in Oxford, where all first year postgraduate students similarly receive 2 - 3 hours of 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 physics, QCD both perturbative and non-perturbative and lattice QCD as listed above).

1.3.13 ORGANIZED SCHOOLS

- FLAVIAnet meeting, Southampton, UK, 14-15 December 2009. *Flavour physics with the Relativistic Heavy Quark action*
- HEP Young Theorists' Forum, Durham, 16-17 December 2009 (40 participants)
- Annual UK Particle Theory Meeting, Durham, 17-19 December 2009 (250 participants)
- YETI 2010 (Young Experimentalists and Theorists Institute), *window to the dark world, cosmology to LHC* (38 participants) IPPP, Durham 12-14 January 2010
- Higgs-Maxwell Meeting, Edinburgh, 10 February 2010
- Workshop on Theory Experiment interplay at LHC, London, 8-9 April 2010 (52 participants)
- BOOST 2010, Oxford, 22-25 June 2010 (63 participants)
- Tools 2010, *Tools for SUSY and the new physics*, Winchester, 29 June-2 July, 2010 (45 participants)
- CKM2010: 6th International Workshop on the CKM Unitarity Triangle, Warwick, 6-10 September 2010 (143 participants)
- iNEXT: the NEXT phase of particle physics, Brighton, 23-24 September 2010 (74 participants)

1.3.14 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.

1.3.15 ESR HIRED (October 1, 2009-September 30, 2010)

- Patrick Fritzsch, hired in Southampton, 24 month contract started October 1, 2008
- Stefano Nicotri, hired in Durham, 12 month contract started November 1, 2008
- Floriana Giannuzzi, hired in Durham, 5 months from January 4, 2010
- Jacobo Ruiz de Elvira, hired in Durham, 3 month contract started March 1, 2010
- Emiliano Molinaro, hired in Durham, 3 month contract started May 3, 2010

1.3.16 ESR PERSONAL CAREER DEVELOPMENT PLAN TUTORING, ADVISING, OPPORTUNITIES

- **Patrick Fritzsch, ESR contract, Southampton**

  Patrick Fritzsch's ESR contract (24 months) ended 30 September 2010. His local advisors have been Jonathan M. Flynn and Christopher T. Sachrajda. He also received guidance from several members of other FLAVIA*net* nodes (Jochen Heitger, Münster; Rainer Sommer, Zeuthen).

  Training, research project and major accomplishments

  As already outlined in last year's report, Patrick Fritzsch received his Ph.D. during his first year as FLAVIA*net* ESR. As a former student at University of Münster, Germany, he is well connected to the FLAVIA*net* node Germany-North and continues working on topics in Heavy Quark Effective Theory (HQET), especially the non-perturbative matching of HQET and QCD in a small physical volume. The first part of results from his Ph.D. studies have already been published, while a second one is in preparation.

  With detailed knowledge about CPS, the Columbia Physics System, a software suite for Lattice QCD calculations, P. Fritzsch did a performance study on the local cluster in Southampton, which was intended to be used for his calculations of the phenomenological coupling $g_{B^*B\pi}$, see also last year's report. The results have shown that the implemented Domain Wall Fermion (DWF) inverter performs too slowly in order to do the desired calculations in a reasonable amount of time. For this reason P. Fritzsch and his collaborators in the RBC/UKQCD collaboration decided to switch the code basis to Chroma and UKhadron. Chroma is another software suite developed in the US lattice community and UKhadron is a derivative of Chroma, used and developed within the UKQCD collaboration. To this end P. Fritzsch has been trained by the local expert in UKhadron, Dr. Dirk Brömmel, and appropriate extensions of the code are now included in UKhadron. Beside its focus on the coupling mentioned above, P. Fritzsch also worked on other main topics of heavy quark physics within the RBC/UKQCD collaboration such as the non-perturbative estimation of the parameters in the relativistic heavy quark (RHQ) action and the calculation of the B-meson decay constant f_B. To achieve a good statistical precision in these calculations it is necessary to use improved sources in combination with certain link-smearing techniques. Various combinations have been explored so far and a discussion about the best performing combination is ongoing.

  To further increase the joint effort of B-physics applications using the RHQ action, the RBC/UKQCD collaboration successfully applied for computing time at Fermilab, USA. The European members of this application are J. Flynn, P. Fritzsch and C. Sachrajda from the UK FLAVIA*net* group in Southampton. As a long term objective these calculations also involve a new estimation of the B^0–$\overline{B}^0$-mixing matrix elements and their ratio $\xi = (f_{B_s}/f_B)\sqrt{\hat{B}_s/\hat{B}}$. If it is known to a sufficient precision, it helps to further constrain the apex of the CKM unitarity triangle from theoretical input and directly compare with experiment. In this long term objective, the computation of the $B^*B\pi$ coupling has a

significant computational overlap and is an important input to the chiral extrapolation of B-meson quantities.

In November 2009 Patrick Fritzsch was invited to give a talk about his research in the Computational Applied Mathematics Seminar at Trinity College Dublin, Ireland. As part of his educational training at Southampton, P. Fritzsch participated as problem class leader in the first year module *Mathematical Methods for Physical Sciences* and as assistant in the *Particle Physics Masterclass* 2010. He also attended several local seminars and meetings organized by the Southampton High Energy Physics theory group (SHEP) and the NeXT Institute and participated in the *International Conference on High Energy Physics* in Paris, France. This allowed him to make contact with researchers from other disciplines than his main field of activity and to broaden his view of current research topics in particle physics phenomenology, collider physics and physics beyond the standard model. Shortly before he left Southampton at the end of September 2010, he also received an invitation from Liverpool University, UK, and will give a talk within the next few months to report about his FLAVIA*net* research. P. Fritzsch successfully applied for a new post-doc position in lattice field theory. His new contract at Humboldt-University of Berlin, Germany, started on 1 October 2010.

Long-term career objectives (next 5 years)

Patrick Fritzsch will continue working on heavy quark physics using non-perturbative methods like the lattice discretization. He will carry on working with members of the FLAVIA*net* nodes in the UK and Germany-North, as well as with colleagues in the US. This includes his current work as well as new research topics. Through his contacts he will continue to profit from the expertise of many researchers in this field. One future application of methods acquired during his time as FLAVIA*net* researcher could be the combination of the Schrödinger functional and DWFs for instance. Together with an Indian colleague, which he met 2009 at the FLAVIA*net* summer school in Les Houches, France, he also started thinking about new applications in Thermal QCD using methods he has been trained in during his employment as ESR.

Recently, his attention has been drawn again to the algorithmic aspect of lattice field theory, especially numerical simulations with more than two dynamical fermions. He will profit from the knowledge obtained during the past 2 years within the RBC/UKQCD collaboration, which uses a mass-degenerate doublet of dynamical light (up and down) quarks and a heavier dynamical strange quark. In the future, P. Fritzsch would like to continue working as researcher and to become a vital member of the high energy physics community.

conferences, workshops, meetings attended

- NeXT physics meeting at RAL, Didcot, UK, October 2009.
- FLAVIAnet meeting, Southampton, UK, December 2009. *Flavour physics with the Relativistic Heavy Quark action*
- NeXT physics meeting, Southampton, UK, January 2010.

– XXVIII International Symposium on Lattice Field Theory, Villasimius, Italy, June 2010. *Computing the $B^*B\pi$ coupling with relativistic heavy quarks and domain wall fermions*

– International Conference on High Energy Physics, Paris, France, July 2010.

– Euroflavour'10, Annual FLAVIAnet Meeting, Munich, Germany, September 2010.

publications

"Non-perturbative improvement of quark mass renormalization in two-flavour lattice QCD", JHEP, **08** (2010) 074 [arXiv: 1004.3978],

His thesis has been published as a 'digital dissertation' on this web site:
`http://nbn-resolving.de/urn:nbn:de:hbz:6-19479503302`

- **Stefano Nicotri, ESR contract, Durham**

Stefano Nicotri started a 12 month ESR position at Durham University on November 1st, 2008. His local advisor was Michael Pennington.

Brief overview of activities

Stefano Nicotri had 1 month of his ESR contract in the reporting period and then became a Research Associate at the Institute for Particle Physics Phenomenology, Durham University.

The research work of Stefano Nicotri concerns the holographic approach to QCD. It is a recently developed analytical approach to the strong coupling regime of the theory of strong interactions. In particular, he has studied the properties of chromodynamics at finite temperature and density, with particular attention to the QCD phase diagram and deconfinement transition. He has developed a mixed analytic-numerical phenomenological model to study the behaviour of the free energy of two static colour sources in hot and dense matter through higher dimensional methods.

He has had the opportunity to join a tutoring programme in physics in Durham University, as part of the training, to improve his teaching skills. He has been a tutor for the whole academic year for 2 groups of eight first-year undergraduate students for the Level 1 *Foundations of Physics* course.

Moreover, he has attended the following conferences in which he has presented his results as a speaker:

– QCD@Work, 20-23 June 2010, Martina Franca, Italy.

– Euroflavour 2010, 8-10 September 2010, Munich, Germany.

He has started a collaboration with Dr. Marco Ruggieri of the Yukawa Institute of Theoretical Physics, Kyoto, Japan.

Long-term career objectives

Finally, Dr Nicotri has had the opportunity to apply for a two-year Postdoc position within the University of Bari. The application has been successful. Then, he plans to continue his academic career, getting a postdoc position from another European research institute, while being open to new experiences in some non-academic environment.

Short-term objectives

Dr Nicotri has produced the following scientific papers describing his results

– arXiv:1009.4829 [hep-ph] (proceeding, to appear on AIP Conference Proceedings Series)
– arXiv:1008.3116 [hep-ph] (submitted to Phys. Rev. Lett.)

His short-term research goals are the study the behaviour of hadrons in a hot and dense medium and the effects of an electromagnetic external field on the QCD phase diagram through holographic models.

- **Floriana Giannuzzi, ESR contract, Durham**

Floriana Giannuzzi started her ESR contract (5 months) on January 4^{th} 2010. Her local advisor was Michael Pennington.

Brief overview of activities

At the Institute for Particle Physics Phenomenology, Durham University, Floriana Giannuzzi has started a collaboration with Adrian Signer, Pietro Falgari and Paul Mellor about *s*-channel *top*-quark production at the LHC. She has also prepared for her PhD final exam, and the title has been awarded at her home institution in Bari, Italy, on April 8^{th} 2010.

The research work of Floriana Giannuzzi concerns the holographic approach to QCD. It is a recently developed approach to the strong coupling regime of the theory of strong interactions. In particular, she has studied the properties of scalar mesons and scalar glueballs

at finite temperature in the phenomenological frameworks known as Soft-Wall model and Hard-Wall model and the deconfinement transition at finite temperatures and densities. She has continued her already existing collaboration with Stefano Nicotri of the IPPP in this research area. Furthermore, she has started to investigate a new issue, dealing with interference effects between *top* decay and production at Next to Leading Order in QCD. The amplitudes for such processes have been computed using an effective theory approach, and the method of region has also been used to get virtual corrections to the tree-level amplitude. The final cross section has been computed through a Monte Carlo integration.

Long-term career objectives

During the period covered by her ESR Fellowship, Ms Giannuzzi developed expertise in the field of theoretical particle physics, as well as in research organization, that she will need in her career. In particular, she has improved her knowledge of quantum field theory, effective field theories, particle phenomenology and computer programming.

She has had the opportunity to apply for a two-year Research Associate position within the University of Bari, in Italy. The application has been successful and she will spend the next two years in Bari, after the end of her ESR contract. She has spent three further months at IPPP as a visitor to complete her work, and she will continue the collaboration with Durham people on other subjects.
After the first postdoc, she plans to continue her academic career, getting a postdoc position from another European research institute.

Short-term objectives

Floriana Giannuzzi has produced the following scientific paper describing her results

– arXiv:1008.3116 [hep-ph] (submitted to Phys. Rev. Lett.)

Her short-term research goals are the study of chiral symmetry breaking in holographic models of QCD and the application of *top* production cross sections to determine some CKM matrix elements.

Conferences

She attended the following conference, giving a seminar:

– CORTONA 2010 - Convegno Informale di Fisica Teorica, Cortona (Italy), 26-29 May 2010.

- **Jacobo Ruiz de Elvira Carrascal, ESR contract, Durham**

Jacobo Ruiz de Elvira started his ESR contract (3 months) on March 1^{st} 2010. His local advisor was Michael Pennington.

Brief overview of activities

The research work of Jacobo Ruiz de Elvira concerns the properties of the light scalars using unitarized Chiral Perturbation Theory, the $N_{\rm c}$ expansion of QCD, and dispersion relations.

During this ESR period, Jacobo has been collaborating with Michael Pennington and David Willson in a project that relates the structure of the $f_0(600)$ or σ meson with Local Duality.

The leading $1/N_{\rm c}$ behaviour of Unitarised Chiral Perturbation Theory (UChPT) distinguishes the nature of the ρ and the σ mesons. At one loop order the ρ is a $\bar{q}q$ meson, while the σ is not. However, semi-local duality between resonances and Regge behaviour cannot be satisfied for larger $N_{\rm c}$, if such a distinction holds. While the σ at $N_{\rm c} = 3$ is inevitably dominated by its di-pion component, Unitarised Chiral Perturbation Theory beyond one loop order reveals that as $N_{\rm c}$ increases above 6-8, the σ has a sub-dominant $\bar{q}q$ fraction up at 1.2 GeV. Remarkably this ensures semi-local duality is fulfilled for the range of $N_{\rm c} \leq 15$, where the unitarisation procedure adopted applies

During this period, he has also been working in the leading-N_c behavior of the masses and transition matrix elements of some low-lying, few-particle configurations in QCD, which toghether with the Nc expansion of UChPT, are used to estimate the proportion of tetraquark/molecule-like (dominant), $q\bar{q}$-like (subdominant) and exotic-like (marginal) configurations in the σ meson.

Finally he also worked in the description of $\pi\pi$ scattering data by imposing simultaneous fulfillment of dispersion relations.

Long-term career objectives

During the period covered by his ESR Fellowship, Jacobo Ruiz de Elvira has improved his knowledge of quantum field theory, effective field theories, analytic approaches to QCD, particle phenomenology and computer programming. He plans to finish his PhD next year

and then, and then continues his academic career, getting a postdoc position from another research institute.

Short-term objectives

Jacobo Ruiz de Elvira has produced the following scientific papers describing his results

- arXiv:1005.4370 [hep-ph] (accepted in Phys. Rev. D)
- arXiv:1009.6204 [hep-ph] (submitted to Phys. Rev. D)

His short-term research goals are to finish the different research projects he has been working on, and to study the structure of the σ meson using the P-matrix formalism.

- **Emiliano Molinaro, Early Stage Researcher on Flavianet in Durham**

Emiliano Molinaro started his ESR contract (3 months) on May 3$^{\rm rd}$ 2010. His local advisors at IPPP were Silvia Pascoli and Michael Pennington.

Brief overview of activities

Emiliano Molinaro spent the final part of his PhD at the Institute for Particle Physics Phenomenology, Durham University, completing his thesis and starting a new collaboration with Silvia Pascoli on topics in part related to his PhD work. He successfully took his PhD exam on the 23$^{\rm rd}$ September 2010 in his home institution SISSA (Scuola Internazionale Superiore di Studi Avanzati), Trieste, Italy. Currently he has a postdoc position at CFTP (Centro de Física Teórica de Partículas) in the Instituto Superior Técnico of Lisbon, Portugal.

The main topics of the research activity of Emiliano Molinaro are related to neutrino physics, flavour physics, astro-particle physics and cosmology. In particular, his interests and efforts were devoted to attempts to explain, in the same physical context, several issues concerning these different fields. Along this line, he studied in detail phenomenological aspects of the leptogenesis mechanism for the generation of the matter-antimatter (baryon) asymmetry of the Universe, which, in see-saw extensions of the Standard Model, is strictly related to the origin of the neutrino masses. He performed a model independent analysis pointing out the correlation of the baryon asymmetry with low energy observables (possibly) measurable in neutrino physics, e.g. absolute neutrino mass scale and

CP violating phases (one Dirac and two Majorana type phases) of the Pontecorvo-Maki-Nakagawa-Sakata (PMNS) neutrino mixing matrix.

The see-saw mechanism of generation of neutrino masses was further investigated in models that can be testable, in principle, at current particle accelerators, including the Large Hadron Collider. This work was completed during his stay at IPPP, relying on the fruitful discussions and suggestions of his local advisor Silvia Pascoli.

Long-term career objectives

During the period covered by his ESR Fellowship, Emiliano Molinaro improved his knowledge of neutrino physics and astro-particle physics. The research activity performed at IPPP and the scientific interactions with PhD students, postdocs and professors of the Institute, allowed him to prepare his PhD defense successfully. New topics of research started in Durham, in particular the physics of Dark Matter, are currently an integral part of his work.

Short-term objectives

Emiliano Molinaro produced the following publication during his ERS collaboration in Durham:

– A. Ibarra, E. Molinaro and S. T. Petcov, *TeV scale see-saw mechanisms of neutrino mass generation, the Majorana nature of the heavy singlet neutrinos and* $(\beta\beta)_{0\nu}$*-decay,* JHEP Volume 2010, Number 9, 1-26, DOI: 10.1007/JHEP09(2010)108.

His short-term research goals are the study of leptogenesis in models which generate radiatively neutrino masses (at one loop level). This class of models also predicts a natural candidate of Dark Matter. The work in progress is made in collaboration with Silvia Pascoli and Michael Schmidt.

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

YEAR 1

1.4.1 OFFERED PH. COURSES (LOCALLY)

- PhD seminar *Baryo- and Leptogenesis,* Aachen, Oct 2006 — Feb 2007.
- PhD and student seminar *Particles, Fields, Strings,* Aachen, Apr 2007 — Jul 2007.
- Course *Quantum Field Theory I,* Aachen, Oct 2006 — Feb 2007.

- Course *Quantum Field Theory II*, Aachen, Apr 2007 — Jul 2007.
- Course *Special Topics in Field Theory*, Aachen, Oct 2006 — Feb 2007.
- Course: *Advanced Particle Physics*, Karlsruhe, Oct 2006 — Feb 2007.
- Course: *Theoretical Particle Physics II*, Karlsruhe, Oct 2006 — Feb 2007.
- Student seminar series: *Modern Particle Physics*, Karlsruhe, Oct 2006 — Feb 2007.
- Student seminar series: *Physics at KLOE and BaBar*, Karlsruhe, Oct 2006 — Feb 2007.
- Ph.D. Course on *Supersymmetry and Grand Unification*, Siegen, Oct 2006 — Sep 2007.
- Ph.D. Course on *Quantum Field Theory*, Siegen, Apr — Jul 2007.
- PhD. Course *Technique and Application of Multiloop Feynman Diagrams*, Siegen, Oct 2006
- PhD. Course *Introduction to Lattice QCD*, Siegen, Oct 2006
- PhD. Course *Conformal Symmetry*, Siegen, May 2007
- Course: *Theoretical Particle Physics I*, Karlsruhe, May — Jul 2007.
- Course: *Theoretical Particle Physics III*, Karlsruhe, May — Jul 2007.
- Student seminar series: *Flavour and Supersymmetry*, Karlsruhe, May — Jul 2007.

1.4.2 OFFERED COURSES at ANY LEVEL of interest for the FLAVIANET

- Ringberg Workshop on Perspectives in Heavy Flavor Physics, Oct 1–6 Oct 2007, organised by *International Max Planck Research School Munich*

1.4.3 VISIT of SENIOR SCIENTISTS from OUTSIDE the NETWORK

- Dr. Chris Quigg, *Fermilab*, Batavia, USA, to Univ. Karlsruhe in September 2006.
- Prof. Gustavo Branco, *Instituto Superior Tecnico*, Lisbon, Portugal, to TU Munich in June/July 2007.
- Prof. Frank Wilczek, *MIT*, Cambridge, USA, to Univ. Karlsruhe in July 2007.
- Prof. Julius Wess, *Univ. Hamburg*, to Univ. Karlsruhe in July 2007.
- Prof. A. A. Pivovarov (INR Moscow) to Univ. Siegen, Sep.2006 until Jan 2007
- Prof. B Ioffe (ITEP Moscow) to Univ. Siegen, May 2007
- Prof. L. Lipatov (PNI St. Petersburg) to Univ. Siegen, Jun. 2007

1.4.4 ORGANIZED SCHOOLS

- *Pre-SUSY07* summer school, 23-25 Jul 2007, Karlsruhe, Germany.

  Flavianet Members participating (with node no.):
  Altmannshofer, Wolfgang, 4; Anastasiou, Charalampos, 9; Asch, Thomas, 4; Bauer, Andreas, 4; Bekavac, Stefan, 4; Bell, Guido, 4; Beltrame, Paolo, 4; Bozzi, Giuseppe, 4; Brein, Oliver, 3; Brod, Joachim, 4; Calibbi, Lorenzo, 1; Campanario, Francisco, 4; Crivellin, Andreas, 4; Davidkov, Momchil, 4; Duling, Björn, 4; Guadagnoli, Diego, 4; Hofer, Lars, 4; Jones Perez, Joel, 1; Kaneko, Satoru, 1; Knopf, Markus, 4; Leone, Debora, 4; Marchetti, Schedar, 4; Mertens, Susanne, 4; Milnik, Michael, 4; Paradisi, Paride, 1; Passemar, Emilie, 9; Salomon, Jens, 4; Seidel, Dirk, 4; Scherer, Dominik, 4; Scherrer, Christian, 4; Schnitter, Karsten, 4; Westhoff, Susanne, 4.

  Participation of others: roughly 170 other participants, mostly PhD students.

- Herbstschule Maria Laach *German School for Graduate Student on High Energy Physics*, Maria Laach, 4–14 Sep 2007.

  Flavianet Members participating:

  Node no. 4: Guido Bell, Wolfgang Dungel, Martin Heck, Thomas Mannel, Benjamin Pecjak, Holger von Radziewski, Susanne Westhoff

  Participation of others: 51 other PhD students, 13 other postdocs and lecturers.

- CERN School of Physics (Lectures on “Flavour Physics and CP Violation”) Trest, 19 Aug – 9 Sep 2007, co–organised by Thomas Mannel.

1.4.5 GENERAL TRAINING

- Course: *Programming for Physicists*, Karlsruhe, Oct 2006 — Feb 2007 and May — July 2007

- Course: *Softskills*, Munich, 24 Nov 2006

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

- Vicent Mateu, ESR contract will start Feb 2008 and end Jan 2009.

1.4.7 ER already selected and committed (their contract will start next year)

- Artyom Hovhannisyan, ER contract starts October 2007, two–year contract.

YEAR 2

1.4.8 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 Hardron 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

1.4.9 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

1.4.10 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

1.4.11 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 (quaterly)
- 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

1.4.12 GENERAL TRAINING

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

1.4.13 ESR HIRED

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

1.4.14 ER HIRED

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

1.4.15 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.

1.4.16 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-$\overline{B}_s$ 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-$\overline{B}_s$ 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 $\Lambda_{\rm QCD}/m_b$. Currently Γ_{12} is known to first oder 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 $b \to u\overline{u}d$ 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 particularly, 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 algenra software. Currrently 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 $\Lambda_{\rm QCD}/m_b$ 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.

YEAR 3

1.4.17 OFFERED PH. COURSES (LOCALLY)

- *Relativistische Quantentheorie*, (lecture, Beneke), RWTH Aachen, Apr 2009 – Jul 2009

- *Ergänzungen zur Relativistischen Quantentheorie*, (lecture, Beneke), RWTH Aachen, Apr 2009 – Jul 2009
- *Seminar "Teilchen und Felder"*, (seminar, Beneke), RWTH Aachen, Apr 2009 – Jul 2009
- *Einführung in die Flavourphysik* (lecture, Nierste), Univ. Karlsruhe, Oct 2008 – Feb 2009
- *B-Physics Lunch*, (seminar, Nierste, Feindt), Univ. Karlsruhe, Oct 2008 – Jul 2009
- *Flavour und Supersymmetrie*, (seminar, Nierste), Univ. Karlsruhe, Oct 2008 – Jul 2009
- *Physik VI (Kerne und Teilchen)*, (lecture, Feindt), Univ. Karlsruhe, Apr 2009 – Jul 2009
- *Forschungsseminar CDF*, (seminar, Feindt), Univ. Karlsruhe, Apr 2009 – Jul 2009
- *Forschungsseminar BELLE*, (seminar, Feindt), Univ. Karlsruhe, Apr 2009 – Jul 2009
- *Theoretische Teilchenphysik I*, (lecture, Steinhauser), Univ. Karlsruhe, Apr 2009 – Jul 2009
- *Seminar über Theoretische Elementarteilchenphysik* (seminar, Buras), TU Munich , Oct 2008 – Feb 2009
- *QCD und Kolliderphysik* (lecture, Hoang), TU Munich, Oct 2008 – Feb 2009
- *Einführung in die Quantenchromodynamik* (lecture, Brambilla), TU Munich, Apr - - July 2009
- *Arbeitsgruppe zur Einführung in die QCD* (seminar, Brambilla), TU Munich, Apr – July 2009
- *Seminar über Effektive Feldtheorien* (seminar, Brambilla), TU Munich, Apr – J uly 2009
- *Einführung in die Quantenfeldtheorie* (lecture, Feldmann), TU Munich, Apr – J uly 2009
- *Seminar über Theoretische Elementarteilchenphysik* (seminar, Feldmann), TU Mun ich, Apr – July 2009
- *General Relatvity* (T. Mannel, Siegen, Oct. 2008 - Feb 2009)
- *Collective Quantum Phenomena: Laser, Superconductivity etc.* (W. Kilian, Siegen, Oct 2008 - Feb 2009)
- *Special Topics in Quantum Field Theory* (T. Mannel, A. Khodjamirian, Siegen, Oct 2008 - Feb. 2009)
- *Special Topics in Quantum Field Theory* (A. Khodjamirian, Siegen, Apr. 2009 - Jul. 2009)

1.4.18 OFFERED COURSES at ANY LEVEL of interest for the FLAVIANET

- *Ringberg Workshop on New Physics, Flavors and Jets*, Apr 26 – May 1st 2009
- Workshop on "Progress and Challenges in Flavour Physics", Primosten (Croatia), September 29-October 3 2009, organized by the Unversity of Siegen and the Rudjer Boskovic Institute, Zagreb (Croatia)

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

- Dr. Gino Isidori, *INFN*, Italy, to TU Munich, Oct 2008.

1.4.20 VISIT of SENIOR SCIENTISTS from OUTSIDE the NETWORK

- Prof. Dr. Ikaros Bigi, *Univ. Notre Dame*, USA, to TU Munich, June – November 2008
- Dr. A. A. Pivovarov, *INR Moscow*, to Univ. Siegen, May 2009 to July 2009.
- Dr. Chris Quigg, *Fermilab*, Batavia, USA, to Univ. Karlsruhe, October – November 2008 and March – May 2009
- Dr. Chris Quigg, *Fermilab*, Batavia, USA, to TU Munich, October – December 2009
- Prof. Dr. Frank Wilczek, *MIT*, Cambridge, USA, to Univ. Karlsruhe, December 2009.

1.4.21 ORGANIZED SCHOOLS

- Herbstschule Maria Laach *German School for Graduate Students on High Energy Physics*, Bautzen (Germany), 8–18 Sep 2009.

  Flavianet Members participating:

  Node no. 4: Christian Fiedler, Andreas Maier, Waldemar Martens, Ananda Landwehr, Emmanuel Stamou, Thomas Mannel, Andreas Rossbach, Tanja Robens

  Participation of others: 50 other PhD students, 13 other postdocs and lecturers.

1.4.22 GENERAL TRAINING

- *Programmieren für Physiker* (lecture, Steinhauser), Univ. Karlsruhe, Oct 2008 – Feb 2009
- *Computational Physics* (lecture, Steinhauser), Univ. Karlsruhe, Oct 2008 – Feb 2009
- *Computational Physics I+II* (lecture, Recksiegel), TU Munich, Oct 2008 – Feb 2009 and Apr – July 2009
- *The Harvest of a Century:* The Discoveries of Modern Physics (Prof. S. Brandt), Oct 2008 – Feb 2009

1.4.23 ESR HIRED

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

1.4.24 ER HIRED

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

1.4.25 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

Vicent Mateu has completed his ESR appointment at the Max-Planck-Institut für Physik (MPI) on January 31 as planned. However, the MPI has decided to employ him as a postdoc afterwards and he continues to work on the topics outlined in the initial career development plan, namely heavy quark physics and jet physics.

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 continue his collaboration with Professor Andre Hoang at 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. Chiral corrections to meson decay constants.

2. Research Skills and techniques: Training in specific new areas, or technical expertise etc: Strengthening his knowledge of multiloop calculations, Effective field theories such as SCET, HQET and Non Relativistic QCD (NRQCD).
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.): Extension of current funding from MPI.
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.

1.4.26 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:
The analysis of the B_s-$\overline{B}_s$ system in the Standard Model is currently in its final stage. 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-$\overline{B}_s$ 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 $\Lambda_{\rm QCD}/m_b$. Currently Γ_{12} is known to first oder in both expansion parameters. We are computing 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 $b \to u\overline{u}d$ 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 profits from the experience of his supervisor with the previous calculation of the α_s corrections. It is planned to publish the result soon.

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 particularly, 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, has joined the project. Dr. Marchetti is paid from national sources. The ER already has a solid record of calculations of higher-order QCD corrections. As for the required training, the ER is currently learning how to renormalize the four-quark operators involved in the calculation and how to factorize infrared effects from his supervisor.

SHORT-TERM OBJECTIVES (1-2 years):
1. Research results: Anticipated publications: One publication soon.
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. The ER's work contract in Karlsruhe has been extended by two months with funding from national sources.

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): We have decided not to involve Dr. Hovhannisyan in teaching activities, because our legal department told us that we will risk to receive reduced funding from the EU, if the ER spends part of his work time on teaching.
6. Anticipated networking opportunities: The ER will attend the relevant topical meetings even after the completion of his ER appointment.
7. Other activities (community, etc) with professional relevance: none

YEAR 4

1.4.27 OFFERED PH. COURSES (LOCALLY)

- PhD seminar *New Developments in Physics beyond the Standard Model*, Aachen, Oct 2009 — Feb 2010.
- *Gravitation und Kosmologie I* (lecture Kühn), KIT, Apr – Jul 2010
- *Symmetries and effective field theories* (lecture Smith), KIT, Apr – Jul 2010,
- *Flavour und Supersymmetrie* (seminar Nierste), KIT, Apr – Jul 2010
- *B physics lunch* (seminar Nierste), KIT, Apr – Jul 2010
- *Path Integrals in Quantum Field Theory* (lecture Mannel), U Siegen, Oct. 2009-Feb. 2010
- *Hadrons in Quantum Chromodynamics* (lecture Khodjamirian), U Siegen, April-July 2010.
- *Special relativity* (lecture, Brambilla), TU Munich, Oct 2009 – Feb 2010
- *Effektive Feldtheorien II* (lecture, Vairo), TU Munich, Oct 2009 – Feb 2010
- *Gruppenseminar über Teilchen- und Kernphysik* (seminar, Brambilla), TU Munich, Oct 2009 – Feb 2010
- *Seminar über Effektive Feldtheorien* (seminar, Brambilla), TU Munich, Oct 2009 – Feb 2010
- *Quantenfeldtheorie II* (lecture, Feldmann), TU Munich, Oct 2009 – Feb 2010
- *QCD und Kolliderphysik* (lecture, Hoang), TU Munich, Oct 2009 – Feb 2010
- *Seminar über Theoretische Elementarteilchenphysik* (seminar, Buras/ Feldmann), TU Munich, Oct 2009 – Feb 2010
- *Einführung in die Quantenfeldtheorie* (lecture, Brambilla), TU Munich, Apr – Jul 2010

- *Seminar über Effektive Feldtheorien* (seminar, Brambilla/Vairo), TU Munich, Apr – Jul 2010

- *Seminar zur Physik der starken Wechselwirkung* (seminar, Brambilla), TU Munich, Apr – Jul 2010

- *Gruppenseminar über Teilchen- und Kernphysik* (seminar, Brambilla), TU Munich, Apr – Jul 2010

- *Gruppentheorie in der Physik* (lecture, Vairo), TU Munich, Apr – Jul 2010

- *Seminar über Theoretische Elementarteilchenphysik* (seminar, Buras/ Feldmann), TU Munich, Apr – Jul 2010

- *Theoretische Elementarteilchenphysik* (lecture, Feldmann), TU Munich, Apr – Jul 2010

- *Proseminar zur Theoretischen Teilchenphysik* (Seminar, Feldmann), TU Munich, Apr – Jul 2010

1.4.28 OFFERED COURSES at ANY LEVEL of interest for the FLAVIANET

- Workshop On Future Opportunities For Open Charm Physics At PANDA, Nov 19–20 2009, organised by *Helmholtz Institute Mainz, Johannes Gutenberg University Mainz*

- Lectures on Monte Carlo methods for high energy physics, Sep 21–25 20 09, organised by *INFN - Laboratori Nazionali di Frascati*

- Colloquium In Memory Of Jan Stern: From Current Algebra to the Standard Model and beyond, Oct 2–3 2009, organised by *Institut Henri Poincare, Paris*

- Lectures on The Physics of Vacuum Polarization: from GeV to TeV scale, Nov 10–13 2009, organised by *INFN - Laboratori Nazionali di Frascati*

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

- Two lectures on *Flavour physics* by U. Nierste (KIT) at *Corfu 2010* summer institute, Aug 29 - Sep 5, Corfu, Greece.

- Radio MonteCarLow Satellite Meeting at International Workshop on e^+e^- collisions from Φ to Ψ, Institute of High Energy Physics, Beijing, China, Oct 13 – 16 2009

- Radio MonteCarLow Satellite Meeting at tau2010 conference, University of Liverpool/LNF, Liverpool, UK, Sep 18 – 19 2010

1.4.30 VISIT of SENIOR SCIENTISTS from OUTSIDE the NETWORK

- Prof. Simon Eidelman (INP Novosibirsk), 13–15 Apr 2010 to Siegen, series of seminars on “Physics of charm: experiment challenges theory”.

- Dr. Chris Quigg, *Fermilab*, Batavia, USA, to TU Munich, Aug – Sep 2010.

1.4.31 ORGANIZED SCHOOLS

- 42. Herbstschule Maria Laach *German School for Graduate Student on High Energy Physics* 07. - 17. September 2010, Maria Laach.

  Flavianet Members participating:

  Node no. 4: Thomas Mannel(organizer),
  PhD Students: Dennis Terhorst, Andreas Gueth, Hendrik Weber, Mark Olschewski, (RWTH Aachen); Felix Wick, Dominik Horn, Eva Popenda, Nikolai Zerf(Karlsruhe); Markus Rammes, Patrick Gelhausen (Siegen), postdoc: Bernd Jantzen (RWTH Aachen, as tutor)

  Participation of others: 45 other PhD students, 12 other postdocs and lecturers.

1.4.32 GENERAL TRAINING

- *Computational Physics I: Fundamental numerical methods* (lecture, Recksiegel), TU Munich, Oct 2009 – Feb 2010

- *Computational Physics II: Simulation of classical and quantum mechanical systems* (lecture, Recksiegel), TU Munich, Apr – Jul 2010

- *Parallelisierung von physikalischen Rechnungen auf GPUs mit CUDA* (seminar, Recksiegel), TU Munich, Apr – Jul 2010

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

YEAR 1

1.5.1 OFFERED PH. COURSES (LOCALLY)

- Ph. D. Course on ”*The Standard Model*”, joint course of Rome-1 and Rome-3 Universities, Winter 2007.

- Ph. D. Course on ”*Experimental Particle Physics*”, joint course of Rome-1 and Rome-3 Universities, Winter 2007.

- Ph. D. Course on "*Effective Field Theories*", joint course of Rome-1 and Rome-3 Universities, Spring 2007.
- 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 2007.

1.5.2 OFFERED COURSES at ANY LEVEL of interest for the FLAVIANET

- Summer Lectures on "Flavour Physics", held by Benjamin Grinstein at Rome-1 University, Summer 2007.

1.5.3 VISIT of SENIOR SCIENTISTS from OUTSIDE the NETWORK

- Vincenzo Cirigliano (Los Alamos, USA): 20 May - 2 June, 2007
- Sacha Davidson (U. of Lyon, France): 1 July - 15 July, 2007
- Benjamin Grinstein (San Diego, USA): 1 May - 30 June, 2007
- P.Q. Hung (U. of Virginia, USA): 12 June - 15 July, 2007

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, 2007).

  This edition of the School has been devoted to theoretical and experimental developments on Flavour and Hadron physics in the wake of LHC commissioning.
  Main Lecutres:
  D. Bryman (Triumph): Rare pi & K decay experiments
  P. Franzini (LNF): The Physics of KLOE
  K. Lane (Boston): Effective Field Theories for LHC physics
  W. Marciano (BNL): The Anomalous Magnetic Moment of the muon
  T. Pich (Valencia): Effective Field Theories for low Energy Physics
  A. Stocchi (Orsay): Recent developments in Beauty and Charm Physics
  A. Vladikas (Rome-2): Flavour Physics on the Lattice

  Total number of students: 35, with 18 students (Ph.D. and post-doc) from other nodes of the Network.

1.5.5 GENERAL TRAINING

- *Programming in C++*, University of Naples, Spring 2007.
- *English Language Course*, Frascati National Laboratories, Winter/Spring 2007.

1.5.6 ESR HIRED (October1, 2006.September 30, 2007)

- Javier Virto, hired in Rome (INFN Rome-1) with a 12 months contract started September 6, 2007 (end September 5, 2008).

1.5.7 ER HIRED (October1, 2006.September 30, 2007)

- None

1.5.8 ER already selected and committed (their contract will start next year)

- Jernej Fesel Kamenik, to be hired in Frascati (INFN National Laboratories in Frascati) for 24 months starting October 2, 2007.

YEAR 2

1.5.9 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.

1.5.10 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 Phyiscs", held by Dieter Zeppenfeld, Summer 2008.

1.5.11 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

1.5.12 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.

1.5.13 GENERAL TRAINING

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

1.5.14 ESR HIRED (October1, 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).

1.5.15 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.

1.5.16 ER HIRED (October1, 2007.September 30, 2008)

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

1.5.17 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 supersymetric 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 $B_{(d,s)} \to \pi K$ 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 postodcotral fellowship that will start after 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 fisrt 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 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 QCD$_2$, $N_c \to \infty$) 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. Theoretical 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 School 2009 (Frascati, May 2009).

- Research skills and techniques:

  During her stay in Rome the fellow will be been 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 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.

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 (comunity, 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 Fesel 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 $b \to s\ell^+\ell^-$ and $s \to d\nu\bar{\nu}$ 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 $Br(B \to D\tau\nu)$ and $Br(B \to \tau\nu)$ has already become available and in particular the $B \to D\tau\nu$ 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 $B_s \to D_s\tau\nu$ 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 $t \to c$ 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 $B \to D\ell\nu$ 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 $B_stoJ/PsiKK$ 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 cosmology 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.

YEAR 3

1.5.18 OFFERED PH. COURSES (LOCALLY)

- Ph. D. Course on "*The Standard Model*", joint course of Rome-1 and Rome-3 Universities, Winter 2009.
- Ph. D. Course on "*Experimental Particle Physics*", joint course of Rome-1 and Rome-3 Universities, Winter 2009.
- Ph. D. Course on "*Flavour Physics*", Pisa University, Spring 2009.
- Ph. D. Course on "*Heavy Flavour Physics*", University of Naples, Spring 2009.

1.5.19 OFFERED COURSES at ANY LEVEL of interest for the FLAVIANET

- Summer Lectures on "Precise SM tests in Kaon Decays"", held by Alexey Sibidanov at LNF, Summer 2009.

1.5.20 VISIT of SENIOR SCIENTISTS from OUTSIDE the NETWORK

- Alexey Sibidanov (BINP, Novosibirsk, Russia): 10 May - 10 August, 2009
- Francesco Sannino (Southern Denmark University, Denmark): 1 July - 15 July, 2009

1.5.21 ORGANIZED SCHOOLS

- XII LNF Spring School in Nuclear, Subnuclear and Astroparticle Physics (INFN National Laboratories in Frascati, Italy, from May 11th to May 15th, 2009.

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

1.5.22 GENERAL TRAINING

- *Programming in C++*, University of Naples, Srping 2009.
- *English Language Course*, Frascati National Laboratories, Winter/Spring 2009.

1.5.23 ESR HIRED (October1, 2008.September 30, 2009)

- Pablo Roig Garces, hired in Frascati (INFN National Laboratories in Frascati) for 9 months starting 5th Jannuay 2009.
- David Anotnio Palao Pomares, hired in Rome (INFN Rome-2) for 12 months starting 15th September 2009.

1.5.24 ESR PERSONAL CAREER DEVELOPMENT PLAN TUTORING, ADVISING, OPPORTUNITIES

- Name: Pablo Roig Garcés
- Department: Physik Department, Technical University Munich
- 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, in particular radiative decays of the lowest-lying states, using effective field theories (EFT) like non-relativistic QCD (NRQCD) and potential NRQCD (pNRQCD). In addition to the intrinsic interest of describing the radiative decay of the J/Ψ into $\eta_c\gamma$, we expect that our study will shed some light into the discrepancies found in measuring the mass of the η_c meson when comparing the values coming from radiative decays of other quarkonium states to the results obtained from $\gamma\gamma$ or $p\overline{p}$ experiments. As noted in (arXiv:0805.0252) the η_c mass is sensitive to the parameterization used for the lineshape. A description as close as possible to the fundamental interaction occurring in Nature is desirable.

Our plan is to use EFT, in particular following the work done by Antonio Vairo, Nora Brambilla and Yu Jia (hep-ph/0512369) that studies the magnetic dipole transitions in quarkonium within this framework, in order to calculate the decay width including the effects of the fragmentation contributions- that happen to be important at low photon energies- making as less assumptions as

possible, so that the result can be checked with experiments -and in particular, with CLEO data (arXiv:0805.0252)-.

Long-term career objectives (over 5 years)

Since the starting of the PhD the fellow has been studying hadron decays of the τ lepton into three pseudoscalar mesons within the framework of Resonance Chiral Theory. This is the main work in his Ph.D. and it is done in collaboration with Antonio Pich, Jorge Portolés and Daniel Gómez-Dumm. Up to now the three pion mode has been revisited and the KKπ one has been fully worked out as well. There are preliminary results in the channel K$\pi\pi$, where Matthias Jamin is also in the team. Further studies have already been started: as that one of the decay $\tau \to P\gamma\nu_\tau$, where P can be π and K; in this case the fellow collaborates with Z.H. Guo, who also benefits from ESR fellowships in the network.

Thanks to a short stay in Milano in the Fall of 2006 the fellow started a collaboration with Nora Brambilla and Antonio Vairo. The purpose of it has been first to understand how the related EFT works and then to apply it to physical problems involving the lightest vector and pseudoscalar quarkonium states within pNRQCD, like the radiative decay of the former into the latter and the subsequent measurement of its mass.

In Spring 2008, the fellow also started a collaboration with Olga Shekhovtsova in order to improve the description of the hadronization of QCD currents in the Monte Carlo generator TAUOLA (Comput.Phys.Commun.64:275-299,1990; 76:361-380,1993) and joined the Working Group on Radiative Corrections and Monte Carlo Generators for Low Energies, a group of worldwide experts aimed at facilitating experimentalist and theoreticians (leaded by Graziano Venanzoni and Henryk Czyz) working in the field to share knowledge, understand each other specific needs an collaborate. The research network FLAVIAnet has a relevant participation in it.

By the same time, and together with Jorge Portolés, Gabriel Amorós and Mart n González Alonso, the fellow has also started a joint work that attempts to describe semileptonic decays of D-mesons including as many constraints as possible to the associated Form Factors coming from QCD and using the technique of Padé approximants to mimic the remaining yet unknown dynamics and learn about it.

The group of Nora Brambilla and Antonio Vairo in Munich has offered to the fellow a perfect environment where to improve his knowledge and expertise in effective field theories. For this reason the department of physics of the Technical University of Munich has been a very suitable place for the fellow to start the abovesaid complex problem in heavy quarkonium Physics. Moreover, this Department has also extremely strong research groups in Flavor Physics (also beyond the SM) and Neutrino Physics. The many seminars held in the Department have helped the fellow to complete his formation in this areas as well.

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

Short-term objectives

- Research result: We expect to publish a paper containing the main results of our research concerning the lineshape of the decay $J\Psi \to \eta_c\gamma$ using EFT.

  Anticipated conference, workshop attendance, courses, and/or seminar presentation: It will be presented in forthcoming conferences and meetings.

  Anticipated publications: Those related to the ones mentioned above.

- Research skills and techniques:

  During his stay in Munich the fellow has been trained in the following topics: Nonrelativistic effective field theories (HQET, NRQED, NRQCD, pNRQED, pNRQCD) and QCD perturbative calculations, both in the lectures by Antonio Vairo and in private discussions with Nora Brambilla and Antonio Vairo. The fellow has also attended the lectures by Alejandro Ibarra in Standard Model and Neutrino Physics. He has also participated in the exercises of all these subjects.

- Research management:

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

- Communication skills:

  During his stay in Munich the fellow has given several informal talks on the results of his research and this has contributed greatly to build his communication skills. He has also participated in international seminars and conferences conveying the results in all areas of his work.

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

  During his stay in Munich the fellow has attended several seminars and colloquia in particle, nuclear and neutrino physics. All this in addition to the lectures listed in the item 'Research skills and techniques'. Although the fellow could not speak German fluently, which made hard him teaching, Antonio Vairo let him teach five hours of his course on EFT, that was taught in English. Even though he has already taught for two years at his home University, it is important for the fellow to have had a first experience teaching in a non-mother tongue language. Another relevant aspect of his specific training was his participation in the School on EFT organized by the network and held in Karlsruhe last September.

- Anticipated networking opportunities:

  After the end of the fellowship, but due to this, the fellow will participate to the VI Vienna Central European Seminar in Theoretical and Particle Physics (devoted this year to EFT) in Vienna, where he will present the results of the collaboration and important contact with scientist of the network will be made.

1.5.25 ESR PERSONAL CAREER DEVELOPMENT PLAN TUTORING, ADVISING, OPPORTUNITIES

- Name: David Antonio Palao Pomares
- Department: INFN sezione di Tor Vergata, Roma (Italy)
- Supervisor: Roberto Frezzotti
- Starting date: September 15th, 2009

Brief overview of research project and major accomplishment expected The research project aims at a non-perturbative computation of renormalization of fermionic operators in lattice QCD (LQCD) with unquenched u, d, s and c quark flavours. This computation is a key step for a first-principle determination of quark masses and several matrix elements of phenomenological interest, such as those relevant for the weak effective Hamiltonian or the moments of hadron structure functions.
For this purpose we plan to employ the gauge ensembles that have been (and are being) produced by the European Twisted Mass (ETM) Collaboration. This collaboration has developed a convenient framework for studying QCD at non-perturbative level by means of efficient simulation algorithms (see Comput. Phys. Commun. **174** (2006) 87; PoS **LAT2005** (2006) 103) and a lattice regularization of the theory based on maximal twisted mass (Mtm) Wilson fermions (see JHEP **0108** (2001) 058, JHEP **0408** (2004) 007, JHEP **0410** (2004) 070). In this way discretization errors linear in the lattice spacing are elegantly and effectively removed, while the bare quark mass parameter that controls the pion mass provides a robust infrared cutoff for all numerical computations.
In the last years the MtmLQCD framework has been successfully employed to study the theory with two (u and d) dynamical flavours: a number of physical observables were computed at several different lattice spacings, $m_{u/d}$-values and volumes, thereby allowing to make contact with the physical situation and obtain physics results for e.g. quark masses (from $m_{u/d}$ to m_b), pseudoscalar meson decay constants (from f_π to f_B), meson and baryon spectrum, electromagnetic hadron form factors, kaon-antikaon oscillations, π–π scattering lengths and a few low energy constants of the QCD chiral effective Lagrangian (among which the chiral condensate).
Recently simulations of MtmLQCD with dynamical u, d (degenerate) as well as s and c (non-degenerate) quarks (so called $n_f = 2 + 1 + 1$ setup) have been performed, based on the lattice fermionic formulation of Nucl. Phys. Proc. Suppl. **128** (2004) 193 and a suitable (Iwasaki) pure gauge action. While preliminary results appear to have good quality (see PoS **LAT2008** (2008)

094), much in line with those obtained with only two dynamical flavours, and further simulations on fine lattices are in progress, a special effort is required to obtain non-perturbative renormalization constants. Indeed, since the scheme where it is convenient to compute the running of the renormalization constants is a "mass-independent" one (in the sense of Phys. Rev. D **8**, 3497 (1973)), namely the RI'mom scheme (see e.g. refs. Nucl. Phys. B **445** (1995) 81; Nucl. Phys. B **531** (1998) 641; JHEP **0408** (2004) 022), the unquenched simulations with heavy c, "lightish" s and light u and d sea quarks, from which the non-renormalized and/or bare quantities are computed, can not be immediately used for the evaluation of the renormalization constants of the operators with non-vanishing anomalous dimension. Rather one has to perform, for each of the considered lattice resolutions, further dedicated simulations, now with $n_f = 4$ degenerate sea quarks at a few different, not too large (and for lattice-technical reasons not too small) mass values. On the resulting gauge configurations one can then compute the Landau gauge correlators that yield, after a suitable analysis (including a safe extrapolation to the zero-mass point), the desired renormalization constants in RI'mom scheme (see e.g. refs. JHEP **0408** (2004) 022 or PoS **LAT2007** (2007) 241).
Our plan amounts precisely to perform such renormalization dedicated simulations, starting from the largest lattice resolution among those studied by the ETM Collaboration in the $n_f = 2+1+1$ setup. Thanks also to the fellow's PhD work, the Monte Carlo code has been successfully tested and several exploratory simulations have already been performed in order to establish the (good) performance of the algorithm as well as the values of the bare mass parameters ($a\mu_{\rm sea}$, $m_{0,\rm sea} \equiv 1/(2\kappa_{\rm sea}) - 4$) at which it is convenient to simulate. This preliminary study allowed to formulate a detailed strategy for the numerical work, which has been started using BlueGeneP (see http://www.idris.fr/eng/Resources/index-babel.html) and MareNostrum (see http://www.bsc.es) supercomputers.
Off-line with respect to the simulations needed to produce $n_f = 4$ gauge ensembles, by using codes already available, the ETM Collaboration is computing the Landau gauge correlators from which the RI'mom renormalization constants will be eventually extracted. An important part of the work, in which the Roman branch of the collaboration has gained a lot of experience in previous quenched and $n_f = 2$ unquenched studies, is precisely the analysis of these Landau gauge correlators. The analysis includes several standard but non-trivial steps: subtraction, wherever needed, of Goldstone pole hadronic contaminations, chiral extrapolation, study of the renormalization scale dependence with the help of (N)NNLO perturbative anomalous dimension. The fellow is expected to significantly contribute to this task too.

Long-term career objectives During his PhD studies the fellow has already become familiar with the most important technical aspects of the research project above above, namely

- twisted mass Wilson fermions and unquenched Monte Carlo simulations; related publications: Physics Letters **B 650** (2007) 304–311; Comput. Phys. Commun. **179** (2008) 695;
- RI'mom scheme and non-perturbative renormalization in LQCD; related publication: JHEP **0804** (2008) 020;
- MtmLQCD with four dynamical quarks; see publication PoS **LAT2008** (2008) 094;

- effective theories and lattice QCD: chiral PT (see publication JHEP **0907** (2009) 043) and HQET (work in progress with V. Gimenez and collaborators about static-charm meson 2- and 3-point correlators for B_c physics).

On these and more general related topics the fellow is expected to benefit from the expertise of various staff members (Rossi, Vladikas, Frezzotti) of the Rome2 theory group who participate in the activities of the ETM Collaboration, as well as from interactions with other lattice experts and theoretical physicists who work in the same Physics Department and in the Rome area. While carrying over the planned reserch project, he is in particular supposed to deepen his knowledge of Quantum Field Theory and Particle Physics phenomenology. Collaboration work with people with a remarkable experience in Monte Carlo simulations and statistical analysis is also expected to improve the fellow's already good skills in the field of Numerical Analysis and Computing. The elements of knowledge in theoretical physics as well as the new skills in the field of numerical simulations statistical analysis that the fellow has acquired (and is expected to acquire) in Rome will hopefully be important in enhancing his future career pattern.

Short-term objectives

- Research result:

  Anticipated publications:

  - S. Reker *et al* [ETM Collaboration], *First results of ETMC simulations with Nf=2 +1+1 twisted mass fermions*, to appear in PoS.
  - D. Palao *et al* [ETM Collaboration], *Performance of PHMC and HMC algorithms in $N_f = 4$ LQCD with twisted Wilson quarks*, to appear in PoS.
  - ETM Collaboration, *Light hadrons from the lattice with dynamical strange and charm*, in preparation.

  Anticipated event attendance:

  - Euroflavour 2009 - Workshop of the Flavianet European Network
  - ETM Collaboration meeting, Bonn, Spring 2010
  - Lattice 2010 conference

- Research skills and techniques:

  During his stay in Rome the fellow has been trained in the following topics: statistical analysis of Monte Carlo data; mass-independent renormalization schemes for LQCD; analysis à la Symanzik of UV cutoff effects in lattice correlators and derived observables.

- 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 Rome the fellow has participated to several common discussions about the research project above and the general scientific activity within the ETM Collaboration.

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

  During his stay in Rome the fellow has attended a few seminars in theoretical particle physics.

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

  During his stay in Rome the fellow has improved his knowledge of English and has learned some basic Italian.

YEAR 4

1.5.26 OFFERED PH. COURSES (LOCALLY)

- Ph. D. Course on "*The Standard Model*", joint course of Rome-1 and Rome-3 Universities, Winter 2010.

- Ph. D. Course on "*Experimental Particle Physics*", joint course of Rome-1 and Rome-3 Universities, Winter 2010.

- Ph. D. Course on "*Heavy Flavour Physics*", University of Naples, Spring 2010.

- Ph. D. Course on "*Quantum Field Theory*", University of Rome-2, Spring 2010.

1.5.27 OFFERED COURSES at ANY LEVEL of interest for the FLAVIANET

- 2010 LNF Spring Institute: Frontiers of Strong Interactions, LNF, Spring 2010.

1.5.28 VISIT of SENIOR SCIENTISTS from OUTSIDE the NETWORK

- Prof. Marteen Golterman (San Francisco), to LNF in July 2010.

1.5.29 ORGANIZED SCHOOLS

- XII LNF Spring School in Nuclear, Subnuclear and Astroparticle Physics (INFN National Laboratories in Frascati, Italy, from May 10th to May 14th, 2010.

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

1.5.30 GENERAL TRAINING

- *Programming in C++*, University of Naples, Srping 2010.
- *English Language Course*, Frascati National Laboratories, Winter/Spring 2010.

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 1

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.

- *Group Theory in Particle Physics*, Warsaw, 2006/7
- *High Energy Physics: Computational and Experimental Methods*, Warsaw, 2006/7
- *Quantum Mechanics*, Katowice, 2006/7
- *Neutrino Physics*, Katowice, 2006/7
- *Elements of Quantum Mechanics and Relativity*, Cracow, 2006/7
- *Introduction to Monte Carlo Methods*, Cracow, 2006/7
- *Heavy Ion Collisions*, Cracow, 2006/7
- *Elementary Particle Interactions: Symmetries and Conservation Laws* , Cracow, 2006/7
- *Astrophysics of Cosmic Rays*, Cracow, 2006/7
- *General Relativity for Physicists*, Cracow, 2006/7

1.6.2 OFFERED COURSES at ANY LEVEL of interest for the FLAVIANET

- *Quantum Field Theory*, Katowice, 2006/7
- *Standard Model*, Katowice, 2006/7
- *Extensions of the Standard Model*, Katowice, 2006/7
- *Astrophysics*, Katowice, 2006/7

- *Meson spectroscopy in p-p collisions,* Katowice, 2006/7
- *Elementary Particle Physics,* Warsaw, 2006/7
- *General Relativity,* Warsaw, 2006/7
- *Particles and Relativity,* Warsaw, 2006/7

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

- Lecture by Janusz Gluza: "Feynman Integrals and Mellin-Barnes Representations" at School: Computer Algebra and Particle Physics 2007, 25-30 March 2007, DESY,Zeuthen
- Training/research stay of PhD student Agnieszka Wapienik at Karlsruhe (node 4): 22/11/06-22/12/06 and 07/01/07-13/02/07

1.6.4 GENERAL TRAINING

- *Polish Language Course for Foreigners Planning to Study in Poland, Katowice*
- *Polish Courses and Introduction to Poland for Socrates-Erasmus Students, Katowice*
- *Polish Courses (at various levels), Warsaw*
- *Summer School of Polish Language, Literature and Culture, Katowice*
- *Statistics for Physicists,* Warsaw
- *Computers and Networks,* Warsaw
- *Parallel Data Processing,* Warsaw
- *Programming Languages,* Katowice
- *Programming in C++,* Katowice
- *Computer Simulations and Analysis of Physical Phenomena,* Katowice

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

- Training/research stay of PhD student Agnieszka Wapienik at Karlsruhe (node 4): 10/11/07-10/12/07

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

- K. A. Kanishchev, the contract started on 17 October 2007, 1 year contract

YEAR 2

1.6.7 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

1.6.8 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

1.6.9 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

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

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

1.6.11 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 it's 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 to Phys.Rev.D. :
D.A. Anipko, M. Cannoni, I.F. Ginzburg, K.A. Kanishev, A.V. Pak, O. Panella. Charge asymmetries in $\gamma\gamma \to \ell^+\ell^- + \nu's$ *(*$\ell = \mu, e$*) 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, Perguia, Italy). In this work charge asymmetry in processes like $\gamma\gamma \to \ell^+\ell^- + \nu's$ 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.

YEAR 3

1.6.12 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.

- *Particles and gravity* , Warsaw, 2008/9
- *Quantum field theory of fundamental interactions* , Warsaw, 2007/8
- *Quantum Mechanics*, Katowice, 2008/9
- *Extensions of the Standard Model*, Katowice, 2008/9
- *Astrophysics of cosmic rays*, Cracow, 2008/9
- *Physics of Relativistic Heavy Ions*, Cracow, 2008/9
- *Elementary Particle Physics* , Cracow, 2008/9

1.6.13 OFFERED COURSES at ANY LEVEL of interest for the FLAVIANET

- *Quantum Field Theory,* Katowice, 2008/9
- *Standard Model,* Katowice, 2008/9
- *Cosmology,* Katowice, 2008/9
- *Pierre Auger Observatory,* Cracow, 2008/9
- *Elementary Particle Physics,* Warsaw, 2008/9
- *Introduction to Supersymmetry,* Warsaw, 2008/9

1.6.14 VISIT of SENIOR SCIENTISTS from OUTSIDE the NETWORK

- Prof. Dr. Fred Jegerlehner, Institut für Physik Humboldt-Universität zu Berlin, to Katowice (6 months)

1.6.15 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

1.6.16 ESR HIRED (October1, 2008.September 30, 2009)

- Sergiy Ivashyn hired for 24 months, started September 1, 2008 until August 31, 2010.

1.6.17 ESR PERSONAL CAREER DEVELOPMENT PLAN TUTORING, ADVISING, OPPORTUNITIES

- Sergiy Ivashyn, ESR, Katowice

  S. Ivashyn has started his 2 year ESR contract in Katowice on September 1, 2008. His host advisor is Prof. dr hab. H. Czyż from the Institute of Physics, University of Silesia in Katowice. Steady link with the home institution (NSC "KIPT", Kharkiv, Ukraine), in particular with Dr. A. Korchin is being kept.

BRIEF OVERVIEW OF RESEARCH PROJECT AND MAJOR ACCOMPLISHMENTS EXPECTED

The research project supports S. Ivashyn's expertise in theoretical studies of hadron interactions by means of phenomenological models. Major part of the training-through-research is devoted to the Monte Carlo methods and Monte Carlo generator development for hadron physics, as to the crucial ingredient of a successful research in this field. The research is focused on two main subjects, relevant to precise determination of muon $g-2$:

1. hadronic contribution to $g-2$ — Radiative Return Method (RRM) and accompanied Final State Radiation modelling;

2. light-by-light contribution to $g-2$ — modelling the two-photon transition form factors and ways for their extraction from data.

Final State Radiation in e^+e^- annihilation to $\pi^+\pi^-\gamma(\gamma)$, $\pi^0\pi^0\gamma(\gamma)$ and $\eta\pi\gamma(\gamma)$ is investigated by means of the PHOKHARA generator, which has been developed, in part, by the Node Coordinator, H. Czyż, and colleagues. In order to improve the quality of the RRM analysis, one has to control the theoretical uncertainty for the final-state photon emission. Current research supports the forthcoming KLOE RRM analysis, in particular, that of the off-ϕ-peak data (e^+e^- center-of-mass energy $\sqrt{s} = 1$ GeV).
The two-photon form factors for pseudoscalar mesons $P = \pi, \eta, \eta'$ and scalar mesons $f_0(600)$, $f_0(980)$, $a_0(980)$ can be extracted from the $e^+e^- \to e^+e^-P$. It allows to study the $\gamma\gamma \to P \to \gamma\gamma$ contributions to the muon $g-2$ as well as the $P \to \gamma\gamma$ decays. The approach and tools for precise extraction of relevant form factors from the experimental data are to be worked out, implementing all necessary radiative corrections. The EKHARA generator for the reaction $e^+e^- \to e^+e^-\pi^+\pi^-$ developed in Katowice made a good starting point for these studies.
The theoretical tools for better understanding of photon-hadron interactions and use at meson factories are the major expected accomplishments. Hopefully they will assist a significant lowering of the theory error on light-by-light contributions to $g-2$ of the muon and the extraction of meson factors.

LONG-TERM CAREER OBJECTIVES (over 5 years)

1. Goals:
To prepare a PhD thesis. Anticipated title: *"Scalar mesons and their decays in the Chiral Resonance Theory"*, anticipated supervisor: Dr. A. Korchin (NSC "KIPT", Kharkiv, Ukraine).
To get a postdoc position in theoretical physics at NSC "KIPT", Kharkiv, Ukraine and a permanent research position after that.
2. What further research activity or other training is needed to attain these goals?
The training obtained previously in Kharkiv and that during the contract at Katowice should be enough to continue work and achieve the listed goals.

SHORT-TERM OBJECTIVES (1-2 years)

1. Research results/Anticipated publications:
Anticipated publications:

- Paper on the reaction $e^+e^- \to \pi^+\pi^-\gamma\ (\eta\pi\gamma)$ as a source of information on the scalar and vector mesons; *with S. Eidelman (Novosibirsk), A. Korchin (Kharkiv) and O. Shekhovtsova (Kharkiv, Frascati).*

- Paper on role of the ISR and ISR-FSR interference in the $e^+e^- \to \pi^+\pi^-\gamma\ (\eta\pi\gamma)$ reactions; *with H. Czyż (Katowice) and A. Korchin (Kharkiv).*

- Paper on implementation of Radiative return method and Resonance Chiral Theory for studies of light-by-light contribution to the muon $g-2$, relevant couplings and form factors; *with H. Czyż (Katowice)*.

- Contribution to paper on physics with the KLOE2 experiment at the ϕ factory, namely, concerning development of tools for $\gamma\gamma$ KLOE2 physics program and EKHARA Monte Carlo generator; *with H. Czyż (Katowice)*.

Anticipated conference, workshop attendance, courses, and /or seminar presentations:

- Annual Workshop and Mid-Term Review Meeting of the European Flavour Physics Network FLAVIAnet "Euroflavour 08", 22-26 September 2008, Durham, UK

  talk: "Momentum dependence of $a_0(980)$ and $f_0(980)$ meson interactions in $\mathrm{R}\chi\mathrm{T}$ face the KLOE data"

- International Workshop on Effective Field Theories: from the Pion to the Upsilon, 2-6 February 2009, Valencia, Spain

  talk: "On modeling the scalar meson dynamics with RChT"

- FLAVIAnet Workshop on Low-energy Constraints on Extensions of the Standard Model, 23-27 July 2009, Kazimierz Dolny, Poland

  talk: "Testing models for final state photon emission in $\pi^+\pi^-$ production at e^+e^- colliders"

- International Conference on Theoretical Physics "Matter to the Deepest", 11-16 September 2009, Ustroń, Poland

  talk: "Radiative return: a progress on FSR tests"

- Presentations at University of Silesia (host University) seminars

  talk: "Resonance chiral theory towards a "swiss knife" for low energy particle interactions" [12/05,2009]

  talk: "Hidden fingerprints of light scalar mesons in radiative decays: the RChT approach" [28/10,2008]

- Presentations at NSC "KIPT", Kharkiv (home Institute) seminars

  talk: "Studies of the ABJ anomaly by means of the EKHARA Monte-Carlo generator (general remarks)" [05/01,2009]

- Presentations at Universität Karlsruhe seminars

  talk: " "Simple" framework for the scalar meson interactions from the Resonance Chiral Theory" [28/01,2009]

- Presentations at the MC FLAVIAnet Working Group meetings, other seminars, workshops and conferences

2. Research Skills and techniques:
Training in specific new areas, or technical expertise etc.:

- Taking part in the rewriting and improvement of the PHOKHARA and EKHARA MC generator code.
- Using Radiative return techniques for different reactions.
- MC development and optimisation methods.
- Using computer algebra system “Maxima”.

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.)
Application for Polish Ministry of Science and Higher Education grant with H. Czyż group (July 2009).
4. Communication skills:

- Language course
- Participation in local seminars at University of Silesia
- Preparing the academic papers.

5. Other professional training
Taking courses at University of Silesia:

- “Quantum Chromodynamics and strong interaction physics,” by F. Jegerlehner; Fall 2008, Spring 2009
- Course on cosmology and gravity by F. Jegerlehner

Participation in scientific schools:

- FLAVIAnet-School Karlsruhe 2009 (FLAVIAnet; Universität Karlsruhe) Karlsruhe, Germany;
  7/09–18/09,2009
- Winter School on High Energy Physics (LAL, Orsay; KhNU and NSC KIPT, Kharkov) Kharkov, Ukraine;
  2/03–5/03,2009

1. Anticipated networking opportunities:

- Discussions with F. Jegerlehner in Katowice.

Co-operation with the following groups:

- Karlsruhe (J.H. Kühn) January 11 — February 10, 2008; January 11 — February 10, 2008;
- Frascati (KLOE) short visits in 2010;
- Valencia (G.Rodrigo) October 22 — November 18, 2009.

2. Other activities (community, etc) with professional relevance:
Taking part in the organisation of the FLAVIAnet Workshop on Low-energy Constraints on Extensions of the Standard Model, Kazimierz, 23-27 July 2009.

1.6.18 PUBLICATIONS DURING THE FIRST 12 MONTHS OF 24

- S. Ivashyn and A. Korchin, "On modeling the scalar meson dynamics with RChT," in proceedings of "International Workshop on Effective Field Theories: from the Pion to the Upsilon," PoS(EFT09)055 [arXiv:0904.4823 [hep-ph]].
- A.Yu. Korchin, S. Ivashyn "Resonance chiral theory and meson production in electron-positron annihilation", pages 223-228
  in proceedings of "XIX Int. Baldin Seminar on High Energy Physics Problems "Relativistic Nuclear Physics and Quantum Chromodynamics" ",
  Editors A.N.Sissakian, V.V.Burov, A.I.Malakhov, S.G.Bondarenko, E.B.Plekhanov, volume I, Dubna, JINR, 2008
- S. Ivashyn and A. Korchin, "Interactions of light scalar mesons from the Resonance Chiral Theory,"
  in proceedings of "Trans-European School of High Energy Physics 2008," Buymerovka (Sumy region), Ukraine

YEAR 4

1.6.19 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.

- *Computer Simulations in Physics* , Warsaw, 2009/10
- *Cosmology* , Warsaw, 2009/10
- *Quantum Mechanics*, Katowice, 2009/10
- *Contemporary methods in experimental physics*, Katowice, 2009/10
- *Systems of Computer Algebra*, Katowice, 2009/10

- *Quantum Mechanics and Relativity*, Cracow, 2009/10
- *Elementary Particle Physics* , Cracow, 2009/10

1.6.20 OFFERED COURSES at ANY LEVEL of interest for the FLAVIANET

- *Neutrino Physics*, Katowice, 2009/10
- *Tests of the Standard Model*, Katowice, 2009/10
- *Cosmology*, Katowice, 2009/10
- *Introduction to Theoretical Physics*, Cracow, 2009/10
- *General Relativity*, Warsaw, 2009/10
- *Particles and Gravity*, Warsaw, 2009/10

1.6.21 VISIT of SENIOR SCIENTISTS from OUTSIDE the NETWORK

- Prof. Dr. Fred Jegerlehner, Institut für Physik Humboldt-Universität zu Berlin, to Katowice (6 months)

1.6.22 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

1.6.23 ESR HIRED (October 1st, 2009 - August 31, 2010)

- Sergiy Ivashyn hired for 24 months, started September 1, 2008 until August 31, 2010.

1.6.24 ESR PERSONAL CAREER DEVELOPMENT PLAN TUTORING, ADVISING, OPPORTUNITIES

- Sergiy Ivashyn, ESR, Katowice

  S. Ivashyn has started his 2 year ESR contract in Katowice on September 1, 2008. His host advisor is Prof. dr hab. H. Czyż from the Institute of Physics, University of Silesia in Katowice. Steady link with the home institution (NSC "KIPT", Kharkiv, Ukraine), in particular with Dr. A. Korchin is being kept.

BRIEF OVERVIEW OF RESEARCH PROJECT AND MAJOR ACCOMPLISHMENTS EXPECTED

The research project supports S. Ivashyn's expertise in theoretical studies of hadron interactions by means of phenomenological models. Major part of the training-through-research is devoted to the Monte Carlo methods and Monte Carlo generator development for hadron physics, as to the crucial ingredient of a successful research in this field. The research is focused on two main subjects, relevant to precise determination of muon $g-2$:

1. hadronic contribution to $g-2$ — Radiative Return Method (RRM) and accompanied Final State Radiation modelling;

2. light-by-light contribution to $g-2$ — modelling the two-photon transition form factors and ways for their extraction from data.

Final State Radiation in e^+e^- annihilation to $\pi^+\pi^-\gamma(\gamma)$, $\pi^0\pi^0\gamma(\gamma)$ and $\eta\pi\gamma(\gamma)$ is investigated by means of the PHOKHARA generator, which has been developed, in part, by the Node Coordinator, H. Czyż, and colleagues. In order to improve the quality of the RRM analysis, one has to control the theoretical uncertainty for the final-state photon emission. Current research supports the forthcoming KLOE RRM analysis, in particular, that of the off-ϕ-peak data (e^+e^- center-of-mass energy $\sqrt{s}=1$ GeV).
The two-photon form factors for pseudoscalar mesons $P=\pi,\eta,\eta'$ and scalar mesons $f_0(600)$, $f_0(980)$, $a_0(980)$ can be extracted from the $e^+e^- \to e^+e^-P$. It allows to study the $\gamma\gamma \to P \to \gamma\gamma$ contributions to the muon $g-2$ as well as the $P\to\gamma\gamma$ decays. The approach and tools for precise extraction of relevant form factors from the experimental data are to be worked out, implementing all necessary radiative corrections. The EKHARA generator for the reaction $e^+e^-\to e^+e^-\pi^+\pi^-$ developed in Katowice made a good starting point for these studies.
The theoretical tools for better understanding of photon-hadron interactions and use at meson factories are the major expected accomplishments. Hopefully they will assist a significant lowering of the theory error on light-by-light contributions to $g-2$ of the muon and the extraction of meson factors.

LONG-TERM CAREER OBJECTIVES (over 5 years)

1. Goals:

To prepare a PhD thesis. Anticipated title: *"Scalar mesons and their decays in the Chiral Resonance Theory"*, anticipated supervisor: Dr. A. Korchin (NSC "KIPT", Kharkiv, Ukraine).
To get a postdoc position in theoretical physics at NSC "KIPT", Kharkiv, Ukraine and a permanent research position after that.

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

The training obtained previously in Kharkiv and that during the contract at Katowice should be enough to continue work and achieve the listed goals.

SHORT-TERM OBJECTIVES (1-2 years)

1. Research results/Anticipated publications:

All the anticipated objectives were obtained and documented in the following publications:

- S. Ivashyn, H. Czyz and A. Korchin, "Radiative Return: a progress on FSR tests," Acta Phys. Polon. B **40** (2009) 3185 [arXiv:0910.5335 [hep-ph]].
- S. Eidelman, S. Ivashyn, A. Korchin, G. Pancheri and O. Shekhovtsova, "e+e- annihilation to (pi0 pi0 gamma) and (pi0 eta gamma) as a source of information on scalar and vector mesons," Eur. Phys. J. C **69** (2010) 103 [arXiv:1003.2141 [hep-ph]].
- G. Amelino-Camelia *et al.*, Eur. Phys. J. C **68** (2010) 619 [arXiv:1003.3868 [hep-ex]].
- H. Czyz and S. Ivashyn, "EKHARA Monte Carlo generator for e+e- to e+e-pi0 and e+e- to e+e- pi+pi- processes," arXiv:1009.1881 [hep-ph] (submitted to Comp. Phys. Commun.)

Anticipated conference, workshop attendance, courses, and /or seminar presentations:
Presentations and seminars:

- 21/06,2010 Two-photon physics of π^0 with EKHARA MC generator, Institut für Kernphysik (IKP), Johannes Gutenberg Universität Mainz, Germany.
- 11/05,2010 A new Monte Carlo for KLOE-2 gamma-gamma physics, Instytut Fizyki, Uniwersytet Śląski, Katowice, Poland
- 30/04,2010 Hot topics in pion two-photon interaction, Instytut Fizyki, Uniwersytet Śląski, Katowice, Poland
- 20/04,2010 How much we can learn about $\gamma^*\gamma^* \to \pi^0$ from KLOE-2: studies with EKHARA Monte Carlo generator, LNF INFN, Frascati, Italy
- 24/11,2009 Comparing the hadronic models of e^+e^- annihilation to $\pi^+\pi^-\gamma$ for Radiative Return at ϕ meson factory, (in Russian) Seminar on the high energy physics and elementary particles; ITP NSC KIPT, Kharkov, Ukraine

- 17/11,2009 Modeling the threshold region in $e^+e^- \to \pi^+\pi^-\gamma$ for Radiative Return at DAPHNE, Instituto de Física Corpuscular (IFIC), Universitat de València, Spain

2. Research Skills and techniques:
Training in specific new areas, or technical expertise etc.:

- Taking part in the rewriting and improvement of the PHOKHARA and EKHARA MC generator code.
- Using Radiative return techniques for different reactions.
- MC development and optimisation methods.
- Using computer algebra system "Maxima".

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.)
Application for Polish Ministry of Science and Higher Education grant with H. Czyż group - the grant was awarded for 3 years and started in April 2010
4. Communication skills:

- Language course
- Participation in local seminars at University of Silesia
- Preparing the academic papers.

5. Other professional training
Taking courses at University of Silesia:

- Course on cosmology and gravity by F. Jegerlehner, Fall 2009, Spring 2010

Participation in scientific schools:

- 26/07–04/08,2010 2010 CTEQ - MCnet Summer School on QCD Phenomenology and Monte Carlo Event Generators, Lauterbad (Black Forest), Germany

1. Anticipated networking opportunities:

- Discussions with F. Jegerlehner in Katowice.

Visits to Other Institutes:

- 22/10–18/11,2009 Institut De Física Corpuscular (IFIC), Universitat de València, Spain.

- 20/11–25/11,2009 ITP NSC KIPT, Kharkov, Ukraine.
- 11/01–10/02,2010 Institute for Theoretical Particle Physics (TTP), Karlsruhe Institute of Technology, Germany.
- 14/04–22/04,2010 Laboratori Nazionali di Frascati, LNF INFN, Italy.
- 25/05–02/06,2010 Laboratori Nazionali di Frascati, LNF INFN, Italy.
- 14/06–25/07,2010 Institut für Kernphysik (IKP), Johannes Gutenberg Universität Mainz, Germany.

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

YEAR 1

1.7.1 OFFERED PH. COURSES (LOCALLY)

- Ph. D. Course on "*The standard model and extensions*", Lund, March-September 2007.
- Ph. D. Course "*Advanced Quantum Field Theory*", Lund, January-May 2007.
- Ph. D. course on "*Relativistic Quantum Mechanics and introduction to Quantum Field Theory*", Lund, September-December 2006.
- Advanced course on "*FYS4170 - Relativistic quantum field theory*", Oslo, September-December 2006.
- Ph.D. course on "*QCD and hadron structure*", Helsinki, September 2006 - December 2006

1.7.2 OFFERED COURSES at ANY LEVEL of interest for the FLAVIANET

- Master course on "*Theoretical Particle Physics*", Lund, November 2006-January 2007.
- Master course on "*General Relativity*", Lund, March-June 2007.
- Undergraduate course "*Theoretical particle physics*", Helsinki, September 2006 - December 2006
- Undergraduate course "*Introduction to quantum field theory*", Helsinki, September 2006 - November 2006

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

Johan Bijnens	7	11 (Mainz)	16-17/1/2007
Jan Eeg	7	10 (Ljubljana)	8-26/1/2007

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

- Talk by J. Eeg in Ljubljana, 11 Jan 2007, *Low-energy aspects of heavy meson decays*
- Talk by J. Bijnens, Mainz, 17 Jan 2007, *Kaon decays and chiral perturbation theory*

1.7.5 ORGANIZED SCHOOLS

- A short school about PWA analysis in conjunction with 4th International Pion-Nucleon PWA Workshop 26-29 Jun 2007, Helsinki, Finland

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

- I. Jemos, ESR contract will start October 2007, end September 2010.

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.

1.7.7 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.

1.7.8 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 particl 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.

1.7.9 GENERAL TRAINING

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

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

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

1.7.11 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 $B \to D\pi$ decays*

1.7.12 ESR hired Octorber 1, 2007- September 30, 2010)

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

1.7.13 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.

YEAR 3

1.7.14 OFFERED PH. COURSES (LOCALLY)

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.

- Ph. D. Course "*Advanced Quantum Field Theory*", Lund, January-May 2009.
- Ph. D. course on "*Relativistic Quantum Mechanics and introduction to Quantum Field Theory*", Lund, September-December 2008.
- Ph. D. Course "*Colours, flavours and their consequences*", Lund, October 2008-February 2009
- Advanced course on "*FYS4170 - Relativistic quantum field theory*", Oslo, August-November 2008.
- Ph. D. course on "*FYS9120 - Advanced quantum field theory*", Oslo, Jan-May 2009.
- Ph. D. course on "*QCD and hadron structure*", Helsinki, Sep-Dec 2008.

1.7.15 OFFERED COURSES at ANY LEVEL of interest for the FLAVIANET

- Master course on "*Theoretical Particle Physics*", Lund, November 2008-January 2009.
- Master course on "*Classical Mechanics*", Lund, March-June 2008.
- Master course on "*The general theory of relativity*", Oslo Jan-May 2009.
- Master course on "*Elementary particle physics*", Oslo Jan-May 2009.
- Master course on "*Experimental High Energy Physics*", Oslo Aug-Nov 2008.
- Master course on "*Theoretical particle physics*", Helsinki, September-December 2008.
- Master course "*Introduction to quantum field theory*", Helsinki, September-December 2008
- Master course "*Path Integrals*", Helsinki, January-April 2009.
- Master course "*General relativity*", Helsinki, January-April 2009.

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

- Joaquim Prades 2(Granada) to 7 (Lund) 15/10-16/11/2008
- Jan Eeg 7 (Oslo) to 10 (Ljubljana) 4-8/5/2009

1.7.17 VISIT of SENIOR SCIENTISTS from OUTSIDE the NETWORK

- Dr. C. Grojean, CERN, to Lund 27-29/5/2009, lectures on Higgs sectors beyond the Standard Model.
- Dr. V Abaev, PNPI, Gatchina, Russia, to Helsinki, 27/10-22/11/2008.

1.7.18 GENERAL TRAINING

- Course: *C++ programming*, Lund, Jan-May 2009

1.7.19 ESR already selected and committed

- Ilaria Jemos, ESR contract started October 2007 and end September 2010.

1.7.20 ESR PERSONAL CAREER DEVELOPMENT PLAN TUTORING, ADVISING, OPPORTUNITIES

– *Ilaria Jemos:* The official report from the latest career development talk is available if wanted (individuell studieplan). These are a standard part of our PhD education and happen twice a year. Discussed are progress towards the PhD, future projects, planning for the dissertation and possible plans and options for career after the PhD. The meetings in 2009 took place in February and early October. The present staus of her PhD studies are that the course work is finished up to completing a programming course. The research work is going as planned. One paper has been published and the work on a new fit of the LECs at NLO using all available NNLO information is progressing. We have also started a new project within hard pion ChPT. She has attended the Flavianet schools and meetings and two more conferences. We have discussed possible options for after obtaining the PhD. Her supervisor in Lund is Johan Bijnens with deputy supervisor Leif Lönnblad and experimental mentor in Frascati Erika De Lucia.

  In addition to the presentations she gave at conferences she has also presented her work at the University of Pavia on 30/10/2008 in a seminar entitled "Costanti a bassa energia (LECs) in Chiral Perturbation Theory" and taken a course on teaching methods at Lund University (Introduction to Teaching in Higher Education, 3 ECTS points).

YEAR 4

1.7.21 OFFERED PH. COURSES (LOCALLY)

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.

– Ph. D. Course "*Advanced Quantum Field Theory*", Lund, January-May 2010.

– Ph. D. course on "*Relativistic Quantum Mechanics and introduction to Quantum Field Theory*", Lund, September-December 2009.

– Ph. D. Course "*Colours, flavours and their consequences*", Lund, October 2009-February 2010 Oslo, Jan-May 2009.

– Ph. D. course on "*Applied Quantum Field Theory*", Helsinki, January-May 2010.

– Ph. D. course on "*Path Integrals*", Helsinki, January-May 2010.

– Ph. D. course on "*Higgs Physics*", Helsinki, September-December 2009.

– Ph. D. course on "*Theoretical Particle Physics*", Helsinki, September-December 2009.

– Advanced course on "*Introduction to Quantum Field Theory*", Helsinki, September-December 2009.
– Master course on "*Theoretical particle physics*", Helsinki, September-December 2009.
– Master course "*Introduction to quantum field theory*", Helsinki, September-December 2009
– Master course "*Path Integrals*", Helsinki, January-April 2010.
– Master course "*General relativity*", Helsinki, January-April 2010.

1.7.22 OFFERED COURSES at ANY LEVEL of interest for the FLAVIANET

– Master course on "*Theoretical Particle Physics*", Lund, November 2009-January 2010.
– Master course on "*General Relativity*", Lund, March-June 2010.
– Master course on "*FYS4170 - Relativistic quantum field theory*", Oslo, August-November 2009.
– Master course on "*FYS4160 - The general theory of relativity*", Oslo Jan-May 2010.
– Master course on "*FYS4560 - Elementary particle physics*", Oslo Jan-May 2010.
– Master course on "*FYS4550 - Experimental High Energy Physics*", Oslo Aug-Nov 2009.
– Master course on "*Theoretical particle physics*", Helsinki, September-December 2009.
– Master course "*Introduction to quantum field theory*", Helsinki, September-December 2009
– Master course "*Path Integrals*", Helsinki, January-April 2010.
– Master course "*General relativity*", Helsinki, January-April 2010.

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

– Johan Bijnens, talk on Leading logarithms in effective field theories, University of Granada, Granada, Spain, 25/2/2010

1.7.24 VISIT of SENIOR SCIENTISTS from OUTSIDE the NETWORK

– Helsinki: J. Stahov, U. Tuzla, Bosnia, 8-19/3/2010
– Lund: Edna Cheung and Kostas Savvidy,Nanjing University, 27-28/4/2010

1.7.25 GENERAL TRAINING

- Course: *Leadershipship*, Lund, February 2010
- Course: *Project Management in Research*, Lund, May-June 2010

1.7.26 ESR HIRED (October1, 2009 -September 30, 2010)

- Ilaria Jemos, October 1 2007- September 30 2010

1.7.27 ESR PERSONAL CAREER DEVELOPMENT PLAN TUTORING, ADVISING, OPPORTUNITIES

- Ilaria Jemos

The official report from the latest career development talk is available if wanted (individuell studieplan). These are a standard part of our PhD education and happen twice a year. Discussed are progress towards the PhD, future projects, planning for the dissertation and possible plans and options for career after the PhD. The meetings in 2010 took place in February and September/October.

The present staus of her PhD studies are that the course work is finished up to completing a programming course. The research work is going as planned. Two papers have been published and the work on a new fit of the LECs at NLO using all available NNLO information is progressing. The work on hard pion perturbation theory has lead to one paper in the reporting period. She has attended the Flavianet schools and meetings and two more conferences. We discussed possible options for after obtaining the PhD. She has take courses on leadership and research project management in the last year as well. The PhD is planned to be finished in spring 2011.

Her supervisor in Lund is Johan Bijnens with deputy supervisor Leif Lönnblad and experimental mentor in Frascati Erika De Lucia.

1.8 Node No. 8: France (CNRS)

YEAR 1

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 06-Jan 07, Orsay)

– Particles and symmetries, second year Masters course (Oct 06-Jan 07, Orsay)
– Introduction to cosmology, second year Masters course (Oct 06-Jan 07, Orsay)
– High-energy astrophysics, second year Masters course (Oct 06-Jan 07, Orsay)
– Weak interaction and unification, second year Masters course (Mar 07-Jun 07, Orsay)
– Strong interaction, second year Masters course (Mar 07-Jun 07, Orsay)
– Neutrinos, second year Masters course (Mar 07-Jun 07, Orsay)
– Relativity and gravitation, second year Masters course (Mar 07-Jun 07, Orsay)
– Relativistic quantum field theory, second year Masters course (L. Lellouch, Oct 06-Jan 07, Marseille)
– Advanced quantum field theory, second year Masters course (M. Knecht, Jan-Mar 07, Marseille)
– The standard model and beyond, second year Masters course (J. Charles, Jan-Mar 07, Marseille)
– Advanced quantum mechanics, second year Masters course (Oct 06-Jan 07, Marseille)
– Particle physics, second year Masters course (Oct 06-Jan 07, Marseille)
– Introduction to astroparticle physics and cosmology, second year Masters course (Oct 06-Jan 07, Marseille)
– Experimental particle physics, second year Masters course (Jan-Mar 07, Marseille)
– Experimental astroparticle physics, second year Masters course (Jan-Mar 07, Marseille)
– General relativity, second year Masters course (Jan-Mar 07, Marseille)
– Geometry and gauge theories, second year Masters course (Jan-Mar 07, Marseille)
– Observational cosmology, second year Masters course (Jan-Mar 07, Marseille)

1.8.2 OFFERED COURSES at ANY LEVEL of interest for the FLAVIANET

– Non-perturbative methods with LHCb connections, PhD French school *Ecole de Gif*, D. Bećirević (24-28 Sep 2007, Paris, France)
– The Standard Model and beyond, 1st PhD French-Ukrainian school, S. Descotes-Genon (9-14 Jul 2007, Mukachevo, Ukraine)
– Flavour physics, 1st PhD French-Ukrainian school, M.H. Schune (9-14 Jul 2007, Mukachevo, Ukraine)
– Chiral Symmetry Breaking, Ph.D. level, Central European School in Particle Physics, M. Knecht (12-20 Sep 2007, Prague, Czech Republic)

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

– D. Bećirević taught courses on quantum field theory during one week in Ljubljana in May 2006 (node 9)

– 5 PhD students (Emmanuel Chang, Benjamin Haas, Justine Serrano, Joao Costa, Jaroslav Trnka) took part in the XIIth Frascati Spring School *Physics in the LHC era* (14-18 May 2007).

1.8.4 VISIT of SENIOR SCIENTISTS from OUTSIDE the NETWORK

– Ikaros Bigi (Notre-Dame-du-Lac, USA) visited Orsay the whole month of July 2007 in order to collaborate with theorists and experimentalists on semileptonic $B \to D$ transitions. An article summarising the outcome of these discussions has been submitted [**?**].

– Andreas Nyffeler (Harish-Chandra Research Institute, Allahabad, India) visited Marseille June 4-9 2007. He gave a seminar on "Little Higgs at the LHC" and discussed theoreticla aspects of the hadronic contribution to $(g-2)_\mu$.

1.8.5 ORGANIZED SCHOOLS

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

– 1st French-Ukrainian school (9-14 Jul 2007, Mukachevo, Ukraine)

  Flavianet ESR participating: E. Lopez (node 2), Y. Amhis, J. Béquilleux (node 8)

  Flavianet ER participating: None (limited to PhD students)

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

  Participation of others : 30 ph. d. students, no postdocs, 10 scientists Coming from: Germany, Poland, Ukraine, Russia, France, Spain, Roumania, Georgia

– Central European School in Particle Physics (12-20 Sep 2007, Prague, Czech Republic)

  Flavianet ESR participating: M. Kolesar, J. Trnka (node 8)

  Flavianet ER participating: None (limited to PhD students)

  Flavianet Members participating: K. Kampf (organiser), J. Novotny, M. Knecht (lecturer) (node 8)

  Participation of others : 40 ph. d. students, no postdocs, 7 scientists Coming from: Germany, Hungary, Poland, Italy, Ukraine, Slovakia, Czech Republic, Spain

1.8.6 GENERAL TRAINING

- English and French language courses provided by CNRS (Orsay) and University Paris-Sud 11 (Oct 06-Jun 07)
- Access to "Formation permanente" courses offered by CNRS (Orsay, Marseille)
- Weekly seminars on particle physics from September to July in Orsay, Marseille and Prague

1.8.7 ESR HIRED (October1, 2006.September 30, 2007)

- Nils Offen, hired in Orsay 1st August 2007 for 2 years

1.8.8 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 and L. Oliver, as well as from postdocs (in particular Dr. E. Kou) and Ph.D. students (E. Chang, B. Haas, B. Malaescu). Experimental aspects of flavour physics will be covered through discussions with A. Stocchi, M.H. Schune and P. Roudeau. In particular, N. Offen will take part in discussions between theorists and experimentalists that are planned at the local level concerning the physics case for Super-B factories. 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 elaborated together with his local advisor will provide N. Offen tools to tackle further issues on the non-perturbative aspects of heavy-quark physics (introduction to lattice methods, effective theories). More specific research objectives have also been proposed concerning the properties of light-cone distribution amplitudes and extensions of sum rules, and on a longer term properties of the B_c meson.

  Training and collaboration

  Since he was hired in Aug. 2007, N. Offen has kept a steady link with his home institution (Univ. of Siegen) through several stays, allowing him to pursue his collaboration with his PhD advisor and his collaborators. He has presented his current work on B form factors in Orsay in May 2007.

  Achievements

  Although hired very recently, N. Offen has started to get in contact with the various

members of the node, and interact with them both on personal and professional levels. He has started learning French through courses provided by CNRS (9 hours per week). He has finished a joint project with his collaborators at Univ. of Siegen which is about to be published, and he is currently working with Dr S. Descotes-Genon on one of the research objectives defined in his CDP.

YEAR 2

1.8.9 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)

1.8.10 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, Buymerovka, Sumy region, Ukraine)
- Flavour physics, PhD Trans-European School of High Energy Physics, M.H. Schune (3-9 Jul 2008, Buymerovka, Sumy region, Ukraine)

1.8.11 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).

1.8.12 VISIT of SENIOR SCIENTISTS from OUTSIDE the NETWORK

- Mikhail Shifman (Univ. of Minnsota, 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.

1.8.13 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, Buymerovka, 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.

1.8.14 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.

1.8.15 ESR HIRED (October1, 2007.September 30, 2008)

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

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

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

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

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

1.8.18 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 $B \to \pi$ form factors and to prepare a new project on $D \to \pi$ and $D \to K$ 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 $B \to \pi$ 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 $B \to \pi$ 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.

YEAR 3

1.8.19 OFFERED PH. COURSES (LOCALLY)

Several PhD programs 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 08-Jan 09, Orsay)
- Particles and symmetries, second year Masters course (Oct 08-Jan 09, Orsay)
- Introduction to cosmology, second year Masters course (Oct 08-Jan 09, Orsay)
- High-energy astrophysics, second year Masters course (Oct 08-Jan 09, Orsay)
- Weak interaction and unification, second year Masters course (Mar 09-Jun 09, Orsay)
- Strong interaction, second year Masters course (Mar 09-Jun 09, Orsay)
- Neutrinos, second year Masters course (Mar 09-Jun 09, Orsay)
- Relativity and gravitation, second year Masters course (Mar 09-Jun 09, Orsay)
- Relativistic quantum field theory, second year Masters course (L. Lellouch, Sep 08-Dec 08, Marseille)
- Advanced quantum field theory, second year Masters course (M. Knecht, Jan-Mar 09, Marseille)
- The standard model and beyond, second year Masters course (J. Charles, Jan-Mar 09, Marseille)
- Particle physics, second year Masters course (Sep 08-Dec 08, Marseille)
- Introduction to astroparticle physics and cosmology, second year Masters course (Sep 08-Dec 08, Marseille)
- Experimental particle physics, second year Masters course (Jan-Mar 09, Marseille)

– Experimental astroparticle physics, second year Masters course (Jan-Mar 09, Marseille)

– General relativity, second year Masters course (Jan-Mar 09, Marseille)

– Geometry and gauge theories, second year Masters course (Jan-Mar 09, Marseille)

– Observational cosmology, second year Masters course (Jan-Mar 09, Marseille)

– Advanced quantum mechanics, second year Masters course (Sep 08-Dec 08, Marseille)

– Statistical mechanics, second year Masters course (Sep 08-Dec 08, Marseille)

– Non-linear dynamics and chaos, second year Masters course (Sep 08-Dec 08, Marseille)

1.8.20 OFFERED COURSES at ANY LEVEL of interest for the FLAVIANET

– Experimental and theoretical particle physics, M1 and M2 courses, M.H. Schune (February 2009, Kiev, Ukraine)

– The Standard Model and beyond, PhD Trans-European School of High Energy Physics, S. Descotes-Genon (Jul 2009, Zakopane, Poland)

– Flavor physics, PhD Trans-European School of High Energy Physics, M.H. Schune (Jul 2009, Zakopane, Poland)

– Lattice flavor physics (L. Lellouch), as part of the Les Houches summer school *Modern perspectives in lattice QCD: Quantum field theory and high performance computing*, August 3–28 2009, Ecole de physique des Houches, France.

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

– 2 PhD students (A. Taydagunov and B. Malaescu) took part in the *Flavianet Summer School on Flavor Physics* (September 7-18 2009, Karlsruhe).

– 2 PhD students (E. Bazzali and G. Vulvert) and 1 ER (A. Ramos) from Marseille took part in the very educational *Colloquium in Memory of Jan Stern*, Paris, 2-3 Sep 2009.

1.8.22 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 gave 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) visited CPT Marseille from 31st August to September 2nd 2008, for collaboration and a seminar.

– Maarten Golterman (San Francisco) was invited by our node to contribute a five lecture course on "Chiral Perturbation Theory" at the les Houches summer school *Modern perspectives in lattice QCD: Quantum field theory and high performance computing*, August 3–28 2009, organized by the network.

– David Kaplan (Univ. of Washington, USA) was invited by our node to contribute a five lecture course on "Chiral Lattice Fermions" at the same school.

– A number of younger experts (from inside and outside the network) were invited to CPT Marseille to present results relevant for the scientific objectives of the network, on topics ranging from lattice calculations of quantities relevant for quark flavor mixing to neutrino flavor mixing and new physics.

1.8.23 ORGANIZED SCHOOLS

Members of the node 8 took part in the organization of two schools for PhD students

– Trans-European School on High-Energy Physics (8-14 July 2009, Zakopane, Poland)

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

  Participation : 50 ph. d. students, no postdocs, 10 scientists
  Coming from: Poland, Ukraine, Russia, Romania, Hungary, Czech Republic, France.

– Les Houches summer school *Modern perspectives in lattice QCD: Quantum field theory and high performance computing*, August 3–28 2009, Ecole de physique des Houches, France. Organizers: L. Lellouch (node 8), R. Sommer (node 11), B. Svetitsky (Tel Aviv), A. Vladikas (node 5)

  The purpose of the School was to impart a deeper theoretical understanding of lattice QCD as well as to survey new, powerful computational methods. Our principal aim was to bring a new generation of young theorists into contact with leading experts in these fields. Important theoretical methods, including chiral lattice fermions, heavy quark effective theories, and chiral perturbation theory were taught alongside computational strategies, algorithms, and the relevance of lattice QCD to high energy experiments.

Flavianet members teaching: P. Hernandez (node 1), L. Lellouch (node 8), M. Lüscher (node 9), O. Philipsen (node 11), S. Schäfer (node 11), R. Sommer (node 11), A. Vladikas (node 5), P. Weisz (node 4)

Flavianet members attending: D. Baumgartner (node 9), F. Bernardoni (node 1), M. Brambilla (node 5), S. Dinter (node 11), S. Di Vita (node 5), X. Feng (node 11), J. Frison (node 8), P. Fritzsch (node 3), D. Hesse (node 11), L. Keegan (node 3), E. Kerrane (node 3), J. Langelage (node 11), L. Orifici (node 5), A. Portelli (node 8), A. Ramos (ER, node 8), F. Virotta (node 11), G. Vulvert (node 8)

Participation of others: a total of 55 Ph.D. students and young postdoctoral fellows attended the schools and 4 additional leading scientists in the field were called upon to lecture (S. Aoki (Tsukuba), T. Appelquist (Yale), M. Golterman (San Francisco), D. Kaplan (U. of Washington)).

1.8.24 GENERAL TRAINING

- English and French language courses provided by CNRS (Orsay) and University Paris-Sud 11 (Oct 08-Jun 09)
- *French language course for foreign scientists*, courses provided by CNRS (Marseille), attended by ER A. Ramos (node 8) from 02/09-06/09, 3h/week.
- 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.

1.8.25 ESR HIRED (October1, 2008.September 30, 2009)

- Nils Offen, hired in Orsay, started his contract 1st August 2007 for 2 years.
- Ruben Garcia-Martin, hired in Orsay, started his contract 1st March 2009 for 1 year.

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

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

1.8.27 ER HIRED (October1, 2008.September 30, 2009)

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

1.8.28 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 adviser 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 flavor physics are covered through discussions with A. Stocchi, M.H. Schune, P. Roudeau (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 adviser 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 flavor 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-Flavor 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 two project on $B \to \pi$ form factors as well as on $D \to \pi$ and $D \to K$ form factors in collaboration with Dr. A. Khodjamirian. He presented his results at the EuroFlavor 07 conference (Orsay, Nov 2007) under the title *V_{ub} and $B \to \pi$ 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 flavor physics and QCD sum rules for PhD students. At the Flavianet school on Flavor Physics (July 2008, Benasque), he gave tutorials for PhD students.

Achievements

Besides learning the basics of French via courses provided by CNRS, 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. N. Offen has finished two projects under the title *Light-cone sum rules for* $B \to \pi$ *form factors revisited* [Duplancic et al., JHEP 0804:014,2008] and *Semileptonic charm decays D —¿ pi l nu(l) and D —¿ K l nu(l) from QCD Light-Cone Sum Rules* [Khodjamirian, arXiv:0907.2842]. He has completed a project with Dr. S. Descotes-Genon, leading to two publications *Three-particle contributions to the renormalisation of B-meson light-cone distribution amplitudes* [S. Descotes-Genon, N. Offen, JHEP 0905:091,2009] and *Renormalization of B-meson distribution amplitudes* [S. Descotes-Genon, N. Offen, arXiv:0904.4687].

– **Ruben Garcia-Martin, Orsay**

R. Garcia-Martin has started hisone-year ESR contract in Orsay on Oct 1st 2008. His local advisor is Dr B. Moussallam, with further local guidance and help from Pr. H. Sazdjian and Drs. V. Bernard and S. Friot. Experimental aspects of flavor physics are covered through discussions with A. Stocchi, M.H. Schune, P. Roudeau (LAL Orsay). As a member of the particle physics group of IPN Orsay, R. Garcia-Martin 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 R. Garcia-Martin inside the Flavianet concerns pion polarizability and photo-photon collisions. This project is aimed at refining the comparisons concerning the pion polarizabilities between the predictions, which are in principle very accurate, based on chiral perturbation theory and the determinations based on experimental data and dispersion relations. The aim is a new determination which uses the high accuracy results from photon-photon scattering producing a pion pair or a kaon-antikaon pair obtained recently by the Belle collaboration, associated with an optimal use of dispersion relations.

The career development plan has been elaborated together with his local advisor to provide R. Garcia-Martin tools to tackle further issues on the non-perturbative aspects of light-quark physics (introduction to lattice methods, effective theories) and to give him an introduction to experimental issues in flavor physics.

Currently R. Garcia-Martin is working on his project on pion polarizability and photo-photon collisions, as well completing his PhD thesis.

Training and collaboration

Since he was hired in August 2008, R. Garcia-Martin has kept a steady link with his home institution (Univ. of Madrid) through several stays. He attended Chiral dynam-

ics 09 (Bern).

At the local level, in addition to collaborating with Dr B. Moussallam, R. Garcia-Martin participated at the local seminars in particle physics.

Achievements

Besides learning the basics of French via courses provided by CNRS, R. Garcia-Martin is currently working on the research objectives defined in his CDP, together with further projects in collaboration with his home institution.

1.8.29 ER CAREER DEVELOPMENT PLAN, TUTORING, ADVISING, OPPORTUNITIES

- Name of fellow: Dr. Alberto Ramos
- Workplace: Centre de Physique Théorique, Marseille.
- Name of Supervisor: Dr. Laurent Lellouch.

Dr. Alberto Ramos began his two-year ER appointment in the Centre de Physique Théorique (Marseille) on October 1, 2008, where he joined the lattice QCD effort of the high-energy theory group, headed by Dr. L. Lellouch. He came from the Universidad Autónoma de Madrid, where he had recently finished his Ph. D. thesis in mathematical physics, under the direction of Prof. A González-Arroyo.

Brief overview of research project and major accomplishments expected

Having been trained during his Ph.D. studies in a different field (the study of classical solutions in field theories), the fellow dedicated the first few months of his appointment to learning about lattice field theory and the applications of lattice QCD to particle physics phenomenology. Besides the regular interactions with his adviser and the weekly group meetings, this training was achieved by attending a number of schools and workshops, amongst which: the month-long summer school "Modern perspectives in lattice QCD: Quantum field theory and high performance computing" at the Ecole de Physique des Houches (Aug. 2009); the "XXVII International Symposium on Lattice Field Theory" (Lattice 2009), Beijing (Jul. 2009); the "Colloquium in memory of Jan Stern: from current algebra to the standard model and beyond" in Paris (Oct. 2009); the course on "Nonperturbative renormalization" in Paris (Mar. 2009); the "Réunion plénière du GDR: Physique subatomique et calculs sur r??eau" in Marseille (Jul. 2008).

Having acquired the necessary skills and developed the relevant computer codes, the fellow is now fully engaged in large scale numerical lattice QCD calculations of phenomenologically important quantities. With the Budapest-Marseille-Wuppertal collaboration, he is developing new methods and strategies to explore the nonperturbative regime of QCD from first principles, keeping full control over all potential sources systematic error.

In this context, has taken responsibility for a number of the team's projects. In particular, he is currently finalizing a study of the ratio F_K/F_π in QCD with $N_f = 2 + 1$ flavors of

sea quarks, based on a series of lattice calculations with three different lattice spacings, large volumes and a simulated pion mass reaching down to about 190 MeV. The results of this calculation allows a controlled test of the Cabibbo-Kobayashi-Maskawa (CKM) model for quark-flavor mixing at the per-mil level, when combined with experimental studies of leptonic pion and kaon decays, such as the 2006 measurement of $K^+ \to \mu^+\nu_\mu(\gamma)$ by KLOE. This work was presented by the fellow at the "XXVII International Symposium on Lattice Field Theory" (Lattice 2009) (to appear in the proceedings) and is also the subject of a paper which he is finalizing ("The ratio F_K/F_π in QCD," Budapest-Marseille Wuppertal Collaboration, in preparation).

He is planning to extend this study to the leptonic decays of the charmed D and D_s mesons. The latter became the subject of some controversy a couple of years ago, when a lattice QCD calculation with a claimed very high accuracy was found to disagree with the world average experimental value by close to four standard deviations. This situation has been partially resolved, thanks to a 2009 measurement by CLEO, but a two and some standard deviation tension remains. Alternatively, these calculations can be used to determine the CKM matrix elements $|V_{cd}|$ and $|V_{cs}|$.

In the coming year, the fellow will also investigate the strange, scalar form factor of the nucleon at zero recoil. Not only is this quantity an important parameter in models of nucleons, but it also enters the cross-section of dark matter candidates with nuclei in many extensions of the standard model. At present, our poor knowledge of this matrix element represents the leading theoretical uncertainty in the interpretation of direct detection experiments.

Long-term career objectives (over 5 years)

– Goals:

  Alberto Ramos' long term goal is to become a fully independent researcher in the field of theoretical particle physics and, more specifically, lattice QCD phenomenology. This means developing a keen understanding of the fundamental questions of particle physics and of how experiment may address them. It further means acquiring and developing all of the tools, field theoretical as well as numerical and algorithmic, required to harness the power of supercomputers to solve challenging problems. It also requires developing communication, fund raising and team management skills, since lattice QCD projects require manpower as well as access to important supercomputing resources.

– Further research activity or other training needed to attain these goals:

  The training most relevant to acquire the competencies described above is to interact with, to learn from and to work with experts in the field. This also means taking responsibility for the realization of projects as well as playing a leadership role in defining their content. It further involves presenting the results of one's work to expert audiences of scientific conferences as well as to the general public.

This direct involvement in projects should be supplemented, when necessary, with training on specific topics, obtained by attending seminars, workshops and schools on certain topics.

All of these research activities and training have already begun at the Centre de Physique Théorique. They will continue in the years to come, with more and more emphasis on assuming a leadership role.

Short-term objectives (1-2 years)

– Research results/Anticipated publications:

  The fellow is currently finalizing a paper on the lattice computation of the leptonic decay constant ratio of kaons and pions. This computation, together with the experimental values of the decay ratios of kaons and pions into leptons, provides stringent tests of the standard model and constraints on physics beyond the standard model. A preliminary version of this work was presented at the "XXVII International Symposium on Lattice Field Theory" (Lattice 2009) in Beijing, and the corresponding contribution to the proceedings will be submitted in the coming days.

  As described in the overview of the research project, the fellow will next undertake a study of the strange content of the nucleon, as well as a study of the leptonic decay of charmed mesons. Both these projects should lead to publications in the year or so to come.

  In addition to publications, a number of conference presentations and seminars are anticipated: University of Wuppertal, SFB meeting (Nov. 09); Euroflavor 2009 (Bari, Nov. 2009); Orsay (Spring 2010); "XXVIII International Symposium on Lattice Field Theory" (Lattice 2010, Sardinia, Jun. 2010); XXXV International Conference on High Energy Physics (Paris, Jul. 2010).

– Research Skills and techniques:

  This past year, Alberto Ramos has invested a significant amount of time in building up solid foundations in the main areas required to perform large scale numerical simulations of QCD relevant for the calculation of important phenomenological quantities. These foundations includes topics ranging from lattice field theory, to algorithms, to the statistical description of data and to effective field theories (e.g. chiral perturbation theory).

  This training has given the fellow the necessary basis to take a leadership role on a number of projects. These skills are being sharpened by regular interaction with Dr. Lellouch and other members of the Marseille team, as well as with members of the collaboration at the University of Wuppertal. They will be further developed by obtaining feedback from experts from within and outside the network, when he presents his results at network events, international conferences and specialized workshops.

– Research management:

The fellow actively participates in the supervision of the work of the team's Ph.D. students. He has also participated in the writing of grants, in particular for requesting supercomputing resources, but not exclusively.

– Communication skills:

  The fellow has had and will continue to have the opportunity to present talks at major international conferences, at workshops and in seminar series at European universities. He is also directly involved in the writing of papers and proceedings pertaining to his work. Moreover, he actively participates in weekly group meetings where he is asked to present progress on his work as well as summaries of topics relevant for the group's research. All of these activities are conducted under the guidance of senior scientists.

– Other professional training:

  The fellow attends regular seminars and colloquia in theoretical and experimental high-energy physics and cosmology, on the Université de la Méditerrannée's campus. He is also given the opportunity to attend seminars in many other fields, ranging from plasma physics, to statistical mechanics, to condensed matter physics and to biophysics.

  The fellow was also taught basic French, through the *French language course for foreign scientists* provided by the CNRS in Marseille, taught over four months (02/09-06/09) with three hours of instruction per week.

– Anticipated networking opportunities:

  The fellow will participate and actively contribute to the General Meetings of the network and to smaller topical workshops. He is also in regular contact with the team's collaborators at the Universities of Wuppertal and Budapest. Frequent travel to Wuppertal is planned for the coming year. Moreover, now that his first results are public, we anticipate travel to other nodes for a more detailed presentation of his work.

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

  Alberto Ramos is involved in developing free software to compute the power distribution in the receiver of a solar thermal plant. This contribution is part of a bigger research project by the Spanish CTAER (Centro Tecnologico Avanzado de Energias Renovables) whose aim is to design software that is able to give optimal solar plant layouts, making this renewable energy more competitive.

YEAR 4

1.8.30 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 09-Jan 10, Orsay)
– Particles and symmetries, second year Masters course (Oct 09-Jan 10, Orsay)
– Introduction to cosmology, second year Masters course (Oct 09-Jan 10, Orsay)
– High-energy astrophysics, second year Masters course (Oct 09-Jan 10, Orsay)
– Weak interaction and unification, second year Masters course (Mar-Jun 10, Orsay)
– Strong interaction, second year Masters course (Mar-Jun 10, Orsay)
– Neutrinos, second year Masters course (Mar-Jun 10, Orsay)
– Relativity and gravitation, second year Masters course (Mar-Jun 10, Orsay)
– Relativistic quantum field theory, second year Masters course (Oct 09-Jan 10, Marseille)
– Advanced quantum field theory, second year Masters course (Jan-Mar 10, Marseille)
– The standard model and beyond, second year Masters course (Jan-Mar 10, Marseille)
– Advanced quantum mechanics, second year Masters course (Oct 09-Jan 10, Marseille)
– Particle physics, second year Masters course (Oct 09-Jan 10, Marseille)
– Introduction to astroparticle physics and cosmology, second year Masters course (Oct 09-Jan 10, Marseille)
– Experimental particle physics, second year Masters course (Jan-Mar 10, Marseille)
– Experimental astroparticle physics, second year Masters course (Jan-Mar 10, Marseille)
– General relativity, second year Masters course (Jan-Mar 10, Marseille)
– Geometry and gauge theories, second year Masters course (Jan-Mar 10, Marseille)
– Observational cosmology, second year Masters course (Jan-Mar 10, Marseille)

1.8.31 OFFERED COURSES at ANY LEVEL of interest for the FLAVIANET

– Experimental and theoretical particle physics, M1 and M2 courses, M.H. Schune (February 2010, Kiev, Ukraine)
– Flavour physics, PhD Trans-European School of High Energy Physics, M.H. Schune (Jul 2010, Bucarest, Romania)

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

– 1 PhD student (G. Toucas) took part in the *Flavianet Summer School on Flavour Physics* (June 21July 2010, Bern) (node 9).
– 1 ESR (P. Roig) visited Valencia and Munich (nodes 1 and 4) several times for training purposes.

1.8.33 VISIT of SENIOR SCIENTISTS from OUTSIDE the NETWORK

– Mikhail Shifman (Univ. of Minnsota, USA) came to take give a lecture in an a conference in the honour of Jan Stern in Paris (nov 2009).

1.8.34 ORGANIZED SCHOOLS

Members of the node 8 took part in the organisation of one school for PhD students

– Trans-European School on High-Energy Physics (7-14 July 2010, Bucarest, Romania)

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

  Participation : 50 ph. d. students, no postdocs, 10 scientists

  Coming from: Poland, Ukraine, Russia, Romania, Hungary, Bulgaria, Taiwan, Montenegro, Germany, France.

1.8.35 GENERAL TRAINING

– English and French language courses provided by CNRS (Orsay) and University Paris-Sud 11 (Oct 09-Jun 10)

– 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.

1.8.36 ESR HIRED (October1, 2009.September 30, 2010)

– Ruben Garcia-Martin, hired in Orsay, started his contract 1st March 2009 and finished on 31st January 2010 (11 months)

– Pablo Roig-Garces, hired in Orsay, started his contract 1st October 2009 and finished on 31st September 2010 (12 months)

1.8.37 ER HIRED (October1, 2008.September 30, 2009)

– Alberto Ramos, hired in Marseille, started 1st October 2008 and finished on 31st September 2010 (24 months)

– **Ruben Garcia-Martin, Orsay**

Name of the fellow: Ruben Garcia-Martin
Department: Institut de Physique Nucléaire, CNRS/Université Paris-Sud 11, France
Name of the supervisor: Bachir Moussallam

1.8.38 ESR PERSONAL CAREER DEVELOPMENT PLAN TUTORING, ADVISING, OPPORTUNITIES

BRIEF OVERVIEW OF RESEARCH PROJECT The aim was to develop an optimized version of the Muskhelishvili-Omnès method as applied to the process of two photons scattering to two pions and of the matching between this approach and the one utilizing the effective low-energy theory of the strong interactions. This is used in conjuction with new experimental results obtained by the Belle collaboration, which have very high statistics. As a result of this work new determinations of the pion polarizabilities (dipole as well as quadrupole) have been obtained as well as new determinations of certain coupling constants in the effective theory. Improved results concerning electromagnetic properties of the scalar mesons are also expected.

LONG-TERM CAREER OBJECTIVES (over 5 years) The sophisticated computer skills learned by R. Garcia-Martin during his stay in Orsay have enabled him to find a position in a Spanish SME located in Madrid and focused on computing services. This work opportunity forced him to end his ESR position one month before its expected deadline. He expects to find a permanent job in the computer industry over the coming years.

SHORT-TERM OBJECTIVES (1-2 years) 1. Research results:

One preprint has been released (arXiv:1006.5373), which has been accepted for publication in Eur. Phys. J.

2. Research Skills and techniques:

R. Garcia-Martin started his one-year ESR contract in Orsay on March 1st 2009. His local advisor was Dr B. Moussallam, with further local guidance and help from Pr. H. Sazdjian and Drs. V. Bernard and S. Friot. Experimental aspects of flavour physics were covered through discussions with A. Stocchi, M.H. Schune, P. Roudeau (LAL Orsay). As a member of the particle physics group of IPN Orsay, R. Garcia-Martin had the opportunity to take part in the regular discussions between theorists and experimentalists on the Orsay campus. The career development plan has been elaborated together with his local advisor to provide R. Garcia-Martin tools to tackle further issues on the non-perturbative aspects of light-quark physics (introduction to lattice methods, effective theories) and to give him an introduction to experimental issues in flavour physics.

3. Research management:

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

4. Communication skills:

Since he was hired in March 2009, R. Garcia-Martin has kept a steady link with his home institution (Univ. of Madrid) through several stays. He attended Chiral dynamics 09 (Bern). At the local level, in addition to collaborating with Dr B. Moussallam, R. Garcia-Martin participated at the local seminars in particle physics. He also followed initiation courses in French.

5. Other professional training

The fellow has not been involved in teaching at the University. However, he has discussed often with the theory groups of IPN and LPT as well as with experimentalists from LAL, all labs being located on the Orsay campus.

– **Pablo Roig-Garces, Orsay**

Name of the fellow: Pablo Roig Garcés
Department: Laboratoire de Physique Théorique, Université de Paris-Sud XI, France
Name of the supervisor: Sébastien Descotes-Genon

BRIEF OVERVIEW OF RESEARCH PROJECT AND MAJOR ACCOMPLISHMENTS EXPECTED The research plan defined in conjunction with P. Roig's supervisor has been to investigate the possible violation of the quark-hadron duality in hadronic tau decays and the hadronic e^+e^- cross-section at low energies. The ratio of inclusive hadronic tau decays (and e^+e^- cross-section) to leptonic decays has been a very useful tool to investiate properties of the strong interaction in a clean way in a rather controlled scenario. Since the forerunner papers where these observables were adressed, this possible duality violation was neglected. However, as the data came more and more precise with time, the errors became so small that this question became of quantitative relevance. Resonance models have been extensively used in the past years in many attempts of quantifying this violation in the extraction of the strong coupling constant at the tau mass scale, $\alpha_S(M_\tau^2)$ and other fundamental parameters of QCD and its effective field theory at very low-energies, Chiral Perturbation Theory. However, such models fail to reproduce the OPE behaviour for QCD. These pertubative conditions QCD imposes on the corresponding correlators were worked out (JHEP 0710:061,2007) and the behaviour in $1/N_C$ (being N_C the number of colours of the gauge group, three in real QCD) and $1/n$ (being n the excitation number of a given resonance in the spectrum) was investigated (JHEP 0806:039,2008). P. Roig has extended these models in order to get a full-fledged model for duality violations, whose imaginary part will be fitted to all available data.

Along with this research project the fellow has continued work with his former collaborators in the study of hadronic decays of the tau lepton in exclusive modes and its implementation in Monte Carlo Generators for low-energy Physics and also in the study of radiative decays of quarkonia. The most important part of the work the fellow has undertaken since the start of his Ph.D. (which will be defended on November, the 15th, 2010) was devoted to the study of hadronic decays of the tau in exclusive channels using Resonance Chiral Theory. This is being done in collaboration with Antonio Pich, Jorge Portolés and Daniel Gómez-Dumm, leading to an improved description of the three pion decay mode (Phys.Lett. B685:158-164, 2010) and the first analysis of the $KK\pi$ decay channel (Phys.Rev. D81:034031, 2010). The decays $\tau \to (\pi/K)^-\gamma$ (arXiv:1009.2542 [hep-ph], with Zhi-Hui Guo) and $\tau \to \eta^{(\prime)}\pi^-\pi^0\nu_\tau$ have also been studied (arXiv:1010.0224 [hep-ph]). A description of the $\tau \to \pi^-\pi^0\nu_\tau$ decay, of prime importance to estimate the hadronic contribution to the vacuum polarization contribution to the anomalous magnetic moment of the muon and the running of the electromagnetic constant up the Z-scale is in preparation, which improves the remarkable precision of the Belle analysis (Phys.Rev.D78:072006,2008).

LONG-TERM CAREER OBJECTIVES (over 5 years)

1. Goals: At the same time, The fellow keeps collaboring with Z. Was and O. Shekhovtsova in the implementation of the relevant hadronic matrix elements in the Monte Carlo event Generator for tau decays TAUOLA (Nucl.Phys.Proc. Suppl.189:78-83,2009; Eur.Phys.J. C66:585-686,2010), which is used both in low-energy and high-energy experiments. Within this project, the $\pi\pi\pi$ and $KK\pi$ have already been coded and precission below the statistical error of the generator has been achieved. The purpose is twofold: one the one hand to complete all needed computations of the relevant two- and three-meson decay modes of the tau (together with the important radiative corrections for the one- and two-meson modes) to analyze data and improve substantially the knowledge of the strong interaction in the $1 \leftrightarrow 2$ GeV region; and on the other one, to implement all these theoretical calculations into the suitable hadronic matrix elements in TAUOLA to provide the experimental community a theory-based tool to study these processes. This will help in many fundamental analyses: the extraction of $\alpha_S(M_\tau^2)$, m_s and V_{us}, the hadronic contribution to the anomalous magnetic moment of the muon and to the QED running coupling constant, leptonic universality tests, charged weak current universality tests, lepton flavour violation searches, etc. In addition to this, the fellow plans to apply the results of his research on duality violations to several phenomenological analyses: like the extraction of $\alpha_S(M_\tau^2)$, the gluon condensate and the low-energy constants of Chiral Pertubation Theory L_{10} and C_{87}.

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

In order to accomplish these long-term career objectives no further training on the theory side is needed, since the fellow already masters the techniques needed to work

with Resonance Lagrangians. However, although he knows the basics of programming in an event generator, he would need some training in order to do this at maximum efficiency. No especial training is required in order to proceed with the phenomenological applications of his research on duality violations, since he is already quite used to manipulate these data.

SHORT-TERM OBJECTIVES (1-2 years)

1. Research results/Anticipated publications: The fellow will submit very soon a short letter with the consequences of his study on $\tau \to \pi^-\gamma\nu_\tau$. This mode is the main source of background for the lepton flavour violating decay $\tau \to \mu\gamma$. This background has been traditionally estimated by the experimental collaborations using PHOTOS. Our results show that although PHOTOS performs very well for most of the photon-energy spectrum, it does not for the large energy region, precisely where this reaction can resemble more easily the $\tau \to \mu\gamma$ decay. This study can be interesting for both BaBar and Belle searches.
The fellow plans also to submit soon a study including tau decays into $\eta^{(\prime)}\pi\pi\nu_\tau$ adding the effect of scalar resonances and to finish the study of duality violations and submit a letter on this research topic. The improved description of the vector form factor to two pions should be ready soon and the analysis of $J\Psi \to \eta_C\gamma$ should follow next (in collaboration with Nora Brambilla and Antonio Vairo).
The next plans for the researcher include estimating the effect of unparticles in the vector form factor to two pions (once the SM description is finished), the completion of the $\tau \to K\pi\pi\nu_\tau$ (with the abovementioned collaborators in tau decays and Matthias Jamin) study and the description of $\tau \to K\eta^{(\prime)}\nu_\tau$ decays (with Matthias Jamin and Rafel Escribano). There is a project with Xian-Wei Kang to study $D_{\ell 4}$ decays using Resonance Lagrangians and heavy-quark symmetry and, as an aplication of the previously mentioned collabration with Zhi-Hui Guo to do lepton universality tests thorugh the ratios $\Gamma(\tau \to \pi^-\gamma\nu_\tau)/\Gamma(\pi^- \to \mu^-\gamma\bar{\nu}_\mu)$ and $\Gamma(\tau \to K^-\gamma\nu_\tau)/\Gamma(K^- \to \mu^-\gamma\bar{\nu}_\mu)$.

2. Research Skills and techniques:

The research skills and techniques needed have already been acquired by the resarch fellow, namely: the use of Effective Field Theories, and particularly, Chiral Perturbation Theory and Resonance Chiral Theory, writing and using an event generator and handling experimental data.

3. Research management:

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

4. Communication skills:

During his stay in Paris the fellow has given several informal talks on the results of his research and this has contributed greatly to build his communication skills. He also presented his work in appropriate conferences and its relevance discussed in suitable working groups : QCD10, TAU10, Confinement IX, 7th/8th Meeting of the WG on Radiative Corrections and Monte Carlo Generators for low-energy Physics and the Flavianet Meeting 2010. He also gave two seminars on these results.

5. Other professional training

The fellow has not been involved in teaching at the University. However, he has discussed often with his advisor's Ph D student, Guillaume Toucas, and his visitor Xian-Wei Kang. Interactions with Michel Davier and his PhD student, Bogdan Malaescu, were also avaialbe.

The fellow has been vice-president of the residents Committee at Colegio de España. There, he organized the outreach talks (30 during the last academic year) and was the scientific coordinator of the outreach day on 'The frontiers of Physics: Particles and Cosmology' with Spanish and French Professors invited. He has also participated in the selection Committee for the selection of new residents for the academic year 2010-2011 and gave two outreach talks himself to a non-specialized audience. His participation in the residents Committee has allowed him to learn management techniques and acquire organizational skills.

1.9 Node No. 9: Switzerland (Universität Bern (UBERN))

YEAR 1

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 2006/07 we had:

  "Introduction to dispersion relations", Jürg Gasser (Bern)

  "The minimal supersymmetric standard model" Christopher Smith (Bern)

  "The standard model", Massimo Passera (Padua)

- At the University of Zurich:

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

1.9.2 OFFERED COURSES at ANY LEVEL of interest for the FLAVIANET

– The Universities of Bern, Lausanne and Zurich offer a wide range of physics courses at the Master level, like Quantum field theory, I and II, and Introduction to experimental particle physics.

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 (October1, 2006–September 30, 2007)

– Emilie Passemar, hired in Bern on July 1, 2007; ESR, 2 years contract

1.9.5 ESR PERSONAL CAREER DEVELOPMENT PLAN TUTORING, ADVISING, OPPORTUNITIES

– **E. Passemar, ESR contract, Bern**
Emilie Passemar has started her two year ESR contract in Bern on July 1, 2007. Local advisor is Gilberto Colangelo. In addition, she is offered guidance by 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 can attend graduate courses on various topic of interest and also language courses (German and scientific English).
Career Development Plan
E. Passemar will finish her PhD in the coming months. Afterwards she will extend her research activity in other directions, in particular in studies of effects of supersymmetric particles in flavour physics at low energy and their connection to collider physics. In addition we plan to study radiative corrections in low energy hadronic processes. For both research directions she can find the necessary expertise locally. Particular attention will be given to giving E. Passemar 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). In July she attended a school on Supersymmetry at the University of Karlsruhe, just before the International conference on Supersymmetry. She is also starting

an active collaboration with various members of the Institute for theoretical physics. We have invited two experimentalists to Bern to give seminars on the $K_{\mu 3}$ decay which is the subject of the PhD of E. Passemar.

Achievements
Since E. Passemar has arrived in Bern she has completed one paper with her advisor in Orsay and other collaborators also belonging to the network.

YEAR 2

1.9.6 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:

"Effective Field Theories", Tobias Hurth (CERN-Zurich)

"Flavour Physics: Theory and Experiment" , Tobias Hurth (CERN-Zurich)

1.9.7 OFFERED COURSES at ANY LEVEL of interest for the FLAVIANET

– The Universities of Bern, Lausanne and Zurich offer a wide range of physics courses at the Master level, like Quantum field theory, I and II, and Introduction to experimental particle physics.

1.9.8 VISIT of SENIOR SCIENTISTS from OUTSIDE the NETWORK

– M. Sainio, Institut für theoretische Physik, Universität Helsinki, Helsinki, Finland, 28.2.08

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

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

– L. Nemenov, CERN, Geneva, Switzerland, 16.4.08

– B. Joffe, Institute for theoretical Physics (ITEP), Moskau, Russia, 20.-24.8.07

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

– S. Gevorkyan, CERN, Geneva, Switzerland, 10.-11.4.08

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

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

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

– A. Alok, Tata Institute of Fundamental Research, Mumbay, India, 5.-8.6.08

1.9.9 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.

1.9.10 ESR HIRED (October1, 2007–September 30, 2008)

– Simone Bifani, hired in Bern on January 1, 2008; ESR, 2 years contract

1.9.11 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. He is stationed at CERN (European Organization for Nuclear Research) were the local advisor is Augusto Ceccucci. Simone is integrated in the research activities of the CERN group lead by Augusto Ceccucci and collaborates to the physics analysis of the data collected by the CERN NA48/2 and NA62 kaon experiments. Simone can interact on daily basis with several other outstanding particle physicists including Luigi Di Lella and Heinrich Wahl. For the more technical parts of his work, he can count on the support of world-leading CERN experts.

  At CERN Simone can attend Academic Lectures of broad interest and excellent seminar series in particle physics and phenomenology. His computing skills can profit from the presence at CERN of leading specialists and outstanding computing facilities.

Career Development Plan
Simone Bifani has defended his doctoral thesis on March 28, 2008. He has now started to analyze the data collected in 2007 by the NA62 Collaboration. Particular interest will be devoted to the study of the radiative $K^+ \to e^+\nu\gamma$ decays. He will also continue to study the requirements for the beam spectrometer ("gigatracker") required to address very rare kaon decays at the CERN SPS. These topics allow Simone to have significant visibility and personal impact on the experiment.

Simone Bifani will be given ample opportunity to present his work to the whole Collaboration and to contribute in network meetings and at international conferences.

Training and collaboration
In June 2008, Bifani attended the PASCOS Conference in Waterloo (Ontario) where he had the opportunity to present the results of his doctoral thesis. These results are soon to be published on a refereed journal.

– **E. Passemar, ESR contract, Bern**
During her first year as ESR in Bern, Emilie Passemar has worked on her 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 $\eta \to 3\pi$. 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 $\eta \to 3\pi$ 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 Benasque (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.

YEAR 3

1.9.12 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 2008/09 we had:

  "Basic Data Analysis", Stephan Durr (Jülich)

  "Looking back at 50 years of particle physics", Heiri Leutwyler (Bern)

  "Group Theory", Uwe-Jens Wiese (Bern)

  "Introduction to Kaluza-Klein Theory", Matthias Blau (Bern)

  "Renormalization Group", Peter Hasenfratz (Bern)
- At the University of Zürich a variety of postgraduate courses are organized and offered in the framework of a Graduate School.

1.9.13 OFFERED COURSES at ANY LEVEL of interest for the FLAVIANET

- The Universities of Bern, Lausanne and Zurich offer a wide range of physics courses at the Master level, like Quantum field theory, I and II, and Introduction to experimental particle physics.

1.9.14 VISIT of SENIOR SCIENTISTS from OUTSIDE the NETWORK

- Prof. S. Mallik, Saha Institute of Nuclear Physics, Calcutta, India, 14.09–12.10.08
- Prof. S. Eidelman, Budker Institute, Novosibirsk, Russia, 14.10.–16.10.08
- Dr. A. Ionissian, Yerevan Physics Institute, Yerevan, Armenia, 15.10.–18.10.08
- Dr. B. Pecjak, University of Mainz, Mainz, Germany, 29.10.–01.11.08
- Prof. M.V. Polyakov, Ruhr-University, Bochum, Germany, 18.12.–20.12.08
- Dr. M. Ivanov, Institute for Nuclear Physics, Dubna, Russia 01.02.–31.03.09 Prof. U. Wolff, Humboldt University, Berlin, Germany, 09.02.–28.02.09
- Prof. H. Asatrian, Yerevan Physics Institute, Yerevan, Armenia, 04.03.–30.04.09
- J. Balog, KFKI Research Institute, Budapest, Hungary, 01.05.–31.05.09
- Dr. Michele Pepe, University of Milano, Milano, Italy, 22.06.–24.07.09
- Prof. B. Ananthanarayan, Indian Institute, Bangalore, India, 01.07.–10.07.09
- Dr. Irinel Caprini, National Institute of Physics and Nuclear Engineering, Bucharest, Romania, 01.07.–10.07.09

1.9.15 GENERAL TRAINING

- The University of Bern, 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.

1.9.16 ESR already selected and committed

- **S. Bifani, ESR contract, Bern** Hired on January 1. 2008 on a two-year contract;
- **E. Passemar, ESR contract, Bern** Hired on July 1. 2007, ESR 2 years contract; the contract has been extended until September 30. 2009 with local money. Dr. Passemar is now on a post-doc position at the University of Valencia.

1.9.17 ESR PERSONAL CAREER DEVELOPMENT PLAN TUTORING, ADVISING, OPPORTUNITIES

- **S. Bifani, ESR contract, Bern**
  Simone Bifani is completing his two year ESR contract which started on January 1. 2008. For the duration of the contract he has been stationed at CERN (European Organization for Nuclear Research) integrated in the research activities of the CERN group lead by Augusto Ceccucci and collaborates to the physics analysis of the data collected by the CERN NA48/2 and NA62 kaon experiments.

  During the contract Simone has continued to perfection the comprehension of the $K^+ \to \pi^+\gamma\gamma$ reaction extending the analysis to the whole NA48/2 data sample and thoroughly assessing the systematic related to the event selection and physics analysis. He has mastered the fitting of the $\gamma\gamma$ mass distribution.

  He developed the simulation of the "gigatracker" detector which is a crucial element to address the very rare kaon decays at the CERN SPS in the future.

  Training and collaboration
  At CERN Simone has attended Academic Lectures of broad interest, workshops and seminars in particle physics and phenomenology. His computing skills have profited from the presence at CERN of leading specialists and oustanding computing facilities.

  Simone Bifani has interacted with Giancarlo D'Ambrosio for clarifications concerning the functional formula. During his period at CERN Simone has supervised a summer student and developed preliminary tools to study the $K^+ \to e^+\nu\gamma$ decays.

  Simone Bifani has presented his work to the whole Collaboration, he has contributed to the network meetings and to international conferences, in particular at the XVII International Conference on Supersymmetry and the Unification of Fundamental Interactions - Boston (USA).

Achievements
During the past year his main achievements have been: the finalization of the $K^{\pm} \to \pi^{\pm}\gamma\gamma$ analysis with the NA48/2 data (to be published in the next months); performing crosschecks to the $K^{\pm} \to e^{\pm}\nu\gamma$ analysis with the NA62 data; the development of the software tools for the NA62 experiment: GEANT4 simulation, data reconstruction and event display.

– **E. Passemar, ESR contract, Bern**
At the end of her first year as ESR in Bern, Emilie Passemar has successfully completed and defended (with honours) her PhD thesis. She has continued her work inside the the Kaon Working group, and on the project in collaboration with G. Colangelo and Stefan Lanz on the dispersive treatment of $\eta \to 3\pi$. She has had regular discussions and exchanges also with other senior members of the node, like J. Gasser, and H. Leutwyler on different aspects related to her research activity.
Career Development Plan
After completing the PhD, Emilie Passemar has started a search for a new job. The search has been very successful, as she quickly got an offer from the University of Valencia. She has also participated to the selection for the "qualification aux fonctions de maitre de conference" in France, which she obtained. This means that in the following four years whenever there is an opening at this level in a french university she can directly applied.
Training and collaboration
At the University of Bern she has attended graduate courses on "Basic Data Analysis", "Group Theory", "Introduction to Kaluza-Klein Theory", and "Renormalization Group" and finally a lecture by H. Leutwyler on "Looking back at 50 years of particle physics". She has also had german courses for beginners.
Achievements
E. Passemar has completed a new original article, has contributed to a long report on flavour physics in the quark sector (which will be published in Physics Report) and a conference proceedings. The latter will soon become an original article.

YEAR 4

1.9.18 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 2009/10 we had:

"Collider Physics and QCD", Thomas Becher (Bern)

"Introduction to Supersymmetric Quantum Mechanics", Urs Wenger (Bern)

"Introduction to Chiral Perturbation Theory", Gilberto Colangelo (Bern)

"Quantum Field Theory in Curved Space-Time", Matthias Blau (Bern)

"Introduction to the Standard Model", Uwe-Jens Wiese (Bern)

"Effective Field Theories", Thomas Becher (Bern)

– At the University of Lausanne and Zürich a variety of postgraduate courses are organized and offered in the framework of a Graduate School.

1.9.19 OFFERED COURSES at ANY LEVEL of interest for the FLAVIANET

– The Universities of Bern, Lausanne and Zurich offer a wide range of physics courses at the Master level, like Quantum field theory, I and II, and Introduction to experimental particle physics.

1.9.20 VISIT of SENIOR SCIENTISTS from OUTSIDE the NETWORK

– Dr. E. Lunghi, Indiana University, Bloomington, USA, 09.01.10–12.01.10
– Prof. G. Palma, Universidad de Santiago de Chile, Santiago, Chile 29.01.10–02.03.10
– Dr. M. Pepe, University of Milano, Milano, Italy 02.03.10–31.03.10
– Prof. F. Feruglio, Universita degli Studi di Padova, Padova, Italy, 10.03.10
– Prof. H. Asatrian, Yerevan Physics Institute, Yerevan, Armenia, 07.04.10–05.06.10
– Prof. B. Ioffe, Institute of Theoretical and Experimental Physics, Moscow, Russia, 20.05.10–25.05.10
– Dr. G. Bergner, University of Münster, Münster, Germany 26.05.10–28.05.10
– Dr. F.-J. Jiang, MIT, Cambridge, USA, 19.06.10–25.06.10
– Prof. Ch. Hofmann, University of Colima, Colima, Mexico, 28.06.10–06.08.10
– Dr. W. Bietenholz, Universidad Autonomo de Mexico, Mexico 08.07.10–28.07.10
– Prof. S. Beane, University of New Hampshire, Durham, USA, 20.06.10–26.06.10
– Prof. A. Schwartz, University of Cincinnati, Cincinnati, USA, 22.06.10–02.07.10
– Prof. S. Stone, Syracuse University, Syracuse, USA, 23.06.10–25.06.10
– Prof. S. Davidson, IPNL, University of Lyon, Villeurbanne, France, 27.06.10–02.07.10

1.9.21 ORGANIZED SCHOOLS

– *Flavianet School on Flavour Physics* List of lecturers and lectures:
  * Silas Beane (New Hampshire) “Effective field theories”
  * Augusto Ceccucci (CERN) “Overview of Kaon Physics”
  * Sacha Davidson (Lyon) “Lepton flavour physics”
  * Antonio Ereditato (Bern) “Neutrino experiments”
  * Uli Haisch (Mainz) “Flavour physics beyond the standard model”
  * Pilar Hernandez (Valencia) “Introduction to lattice QCD”
  * Tobias Hurth (CERN, Mainz) “Flavour physics in the standard model”
  * Thomas Mannel (Siegen) “Effective theories for heavy quarks”
  * Alan Schwartz (Cincinnati) “Recent results in B physics”
  * Sheldon Stone (Syracuse) “LHCb physics”
  * Hartmut Wittig (Mainz) “Recent lattice results”

  Flavianet Members participating:
  Benages Aparici, Nuria Carrasco Vela, Alejandro Celis, Alberto Filipuzzi and Juan Garcia Herrero from Node 1;
  Diogo Boito and Jaume Tarrús from Node 2;
  Elaine Goode and David Jones from Node 3;
  Stefan Gadatsch, Charlotte Hellmann, Massimiliano Procura and Denis Rosenthal from Node 4;
  Flavio Archilli from Node 5;
  Ilaria Jemos from Node 7;
  Guillaume Toucas and Petr Vasko from Node 8;
  John Bulava, Martin Hoferichter, Kathryn Polejaeva and Sebastian Schneider from Node 11.

  Participation of others: In addition there were 18 local participants, mostly PhD students and 3 from outside Europe.

1.9.22 GENERAL TRAINING

– The University of Bern, 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.

1.10 Node No. 10: Austria (Universität Wien)

YEAR 1

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 FLAVIA*net* topics are:

- Seminar on Particle Physics, winter term 2006/2007, summer term 2007
- Privatissimum for PhD students of theoretical physics, winter term 2006/2007
- Seminar on Noncommutative Quantum Field Theory, winter term 2006/2007

1.10.2 OFFERED COURSES at ANY LEVEL of interest for the FLAVIANET

- Course and Exercises: Particle Physics 1, winter term 2006/2007
- Course and Exercises: Particle Physics 2, summer term 2007
- Course: Quantum Field Theory and Noncommutative Geometry, summer term 2007
- Course: Tensors, Spinors, Twistors and all that, winter term 2006/2007
- Course: Entanglement, Decoherence and Geometry of Quantum Systems, winter term 2006/2007
- Course: Physics with Differential Forms, summer term 2007
- Course: Quantum Information, Entanglement and Geometry, summer term 2007
- 3rd Vienna Central European Seminar on Particle Physics and QFT, 1-3 December 2006

1.10.3 VISIT of SENIOR SCIENTISTS from OUTSIDE the NETWORK

- Wolfgang Hollik (MPI Munich) October - December 2006

1.10.4 GENERAL TRAINING

- Practical Course: Computers in Theoretical Physics 1, winter term 2006/2007
- Practical Course: Computers in Theoretical Physics 2, summer term 2007

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

- Martin Zdráhal, January 2008 – December 2009

Year 2

1.10.6 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 FLAVIA*net* 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

1.10.7 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

1.10.8 VISIT of SENIOR SCIENTISTS from OUTSIDE the NETWORK

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

1.10.9 GENERAL TRAINING

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

1.10.10 ESR

– Martin Zdráhal, January 2008 – December 2009

1.10.11 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 $K \to 3\pi$ 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 $K \to 3\pi$ decays at the FLAVIA*net* 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 FLAVIA*net* group in Marseille allowed him fruitful scientific discussions on the $K \to 3\pi$ 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.

YEAR 3

1.10.12 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 FLAVIA*net* topics are:

- Seminar: Particle Physics, winter term 2008, summer term 2009
- Seminar: Noncommutative Geometry and Strings, winter term 2008, summer term 2009

1.10.13 OFFERED COURSES at ANY LEVEL of interest for the FLAVIANET

- Course and Exercises: Introduction to Particle Physics, winter term 2008
- Course and Exercises: Particle Physics II - Quantum Field Theory and Particle Physics, summer term 2009
- Course: The Path Integral in Quantum Mechanics and Quantum Field Theory, summer term 2009
- Course: Tensors, Spinors, Twistors and all that, winter term 2008 summer term 2008
- Course and exercises: Relativity and Cosmology , winter term 2008
- 5th Vienna Central European Seminar on Particle Physics and QFT (Highlights in Computational Quantum Field Theory), November 28 - 30, 2008

1.10.14 VISIT of SENIOR SCIENTISTS from OUTSIDE the NETWORK

- Vincenzo Cirigliano (Los Alamos National Laboratory, USA), Sept. 2008
- Amarjit Soni (BNL, USA), Dec. 2008
- B. Ananthanarayan (Centre of High Energy Physics, India), April 2009
- Ivica Picek (Zagreb, Coatia), May 2009

1.10.15 GENERAL TRAINING

- Language Courses: German
- Course and exercises: Scientific Computing, winter term 2008, summer term 2009

1.10.16 ESR

- Martin Zdráhal, January 1, 2008 – December 31, 2009
- Pere Masjuan Queralt, September 15, 2009 – September 14, 2010

1.10.17 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 writing up 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 $K \to 3\pi$ 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 presents 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. A training in teaching skills is provided by the supervision of students in exercise classes. 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 a research paper with his advisor in Prague and two contributions to Conference Proceedings. During the last year, he has presented the current status of his work at the FLAVIA*net* Meeting in Durham, at the International Workshop on Effective Field Theories in Valencia and the Chiral Dynamics Workshop in Bern. He has attended the Winter School on Nuclear- and Particle Physics in Schladming. Visits in Marseille and Prague allowed him fruitful scientific discussions on his research project. Martin Zdráhal had the opportunity to improve his teaching skills by supervising students at the University of Vienna.

– **Pere Masjuan Queralt, ESR contract, Vienna**
Pere Masjuan has started his one-year ESR contract on September 15, 2009. His local advisor is Helmut Neufeld with additional local guidance by Gerhard Ecker.

Career Development Plan
Pere Masjuan is presently finishing the work on his doctoral thesis which he had started in Barcelona under the supervision of Santi Peris (node 2). His current research activities are mainly concerned with the analytical approximations to QCD: from phenomenological Lagrangians at low energy to QCD sum rules, through math-

ematical approximant tools, as Minimal Hadronic Approximation and, beyond, Padé Theory. In collaboration with Oscar Catà, Rafael Escribano, Santi Peris, Juan Jose Sanz Cillero and Javier Virto, he is applying these different methods to the treatment of two-point Green functions such as the $VV - AA$ correlator and the vacuum polarization function of a heavy quark, form factors and also unitarization methods. He has also studied studied the decay $\eta' \to \eta\pi\pi$ in different chiral invariant approximations. After completion of his PhD he will extend his research activity in other directions, in particular in studies of three- and four-point Green functions, electromagnetic effects in chiral perturbation theory, resonance chiral theory, the relation of ADS/CFT and theories related with Large N_c, Regge theory and resonances. He would also like to extend Padé Theory to other areas where this tool has not yet been used.

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 has attended the FLAVIA*net* summer school hosted at Karlsruhe Institute of Technology in September 2009. He finds the opportunity for research collaborations inside and outside this node. At present, he is involved in an active collaboration with Rafael Escribano, H.Z. Guo, Santi Peris, Juan José Sanz Cillero (node 2), Oscar Catà and Javier Virto (node 5) and with Gerhard Ecker and Helmut Neufeld (node 10).

Achievements

Since Pere Masjuan has arrived in Vienna he has completed a contribution to the Proceedings of Science in connection with the 6th International Workshop on Chiral Dynamics in Bern. He has also passed a German exam (level A2/1) with excellent grades.

YEAR 4

1.10.18 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 FLAVIA*net* topics are:

- Seminar: Particle Physics, winter term 2009, summer term 2010
- Seminar: Noncommutative Geometry and Quantum Field Theory, summer term 2010
- Course: Geometry, Gravitation and Gauge Theory, winter term 2009
- Course: Gravitation and Quantum Theory, summer term 2010

1.10.19 OFFERED COURSES at ANY LEVEL of interest for the FLAVIANET

- Course and Exercises: Introduction to Particle Physics, winter term 2009

– Course and Exercises: Particle Physics II - Quantum Field Theory and Particle Physics, summer term 2009
– Course: Lie Groups and Lie Algebras for Physicists, summer term 2010
– Course and exercises: Relativity and Cosmology, winter term 2009, summer term 2010
– Seminar: Chiral Perturbation Theory, winter term 2009
– Seminar: New Developments in Neutrino Physics, summer term 2010
– Seminar: Seminar Series Particles and Interactions, summer term 2010

1.10.20 VISIT of SENIOR SCIENTISTS from OUTSIDE the NETWORK

– Thomas Schwetz (Max-Planck-Institute Heidelberg), March 2010
– Peter Fierlinger (TU Munich), May 2010
– Valentin I. Zakharov (Max-Planck-Institute Munich), May 2010
– Henri Verschelde (Gent University), May 2010
– Jihn E. Kim (Seoul National University), June 2010

1.10.21 GENERAL TRAINING

– Language Courses: German
– Course and exercises: Scientific Computing, winter term 2009, summer term 2010

1.10.22 ESR

– Martin Zdráhal, January 1, 2008 – December 31, 2009
– Pere Masjuan Queralt, September 15, 2009 – September 14, 2010

1.10.23 ESR PERSONAL CAREER DEVELOPMENT PLAN TUTORING, ADVISING, OPPORTUNITIES

– **Martin Zdráhal, ESR contract, Vienna**
Martin Zdráhal stayed at the University of Vienna with a two-year ESR contract (January 1, 2008 - December 31, 2009). In January 2010 he moved to the Physics Department of Charles University in Prague.

– **Pere Masjuan Queralt, ESR contract, Vienna**
Pere Masjuan stayed at the University of Vienna with a one-year ESR contract (September 15, 2009 - September 14, 2010). He received his PhD at the UA Barcelona in December 2010. In collaboration with Gerhard Ecker and Helmut Neufeld, he published a paper on chiral extrapolation and the determination of low-energy constants from lattice data. Together with Santi Peris from Barcelona, he completed a work on Pade theory applied to the vacuum polarization of a heavy quark. He was offered a Postdoc position at the University of Granada where he moved after the end of his contract in September 2010.

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 1

1.11.1 OFFERED PH. COURSES (LOCALLY)

– Ph. D. Tutorial on "*Conformal invariant quantum field theory*" Berlin, October 2006-February 2007

– Ph. D. Tutorial on "*Schrödinger functional and chiral lattice fermion*", Berlin, April-July 2007

– Ph. D. Course on "*Quantum Chromodynamics*", Münster, April - July 2007.

– Ph. D. Course on "*Introduction to the Standard Model of Elementary Particle Theory*", Münster, October 2006 - February 2007.

– Ph. D. Tutorial on "*Effective field theories and lattice QCD*", Mainz, April - July 2007

1.11.2 OFFERED COURSES at ANY LEVEL of interest for the FLAVIANET

– Course on "Lattice QCD and effective field theories", Bonn, WS 2006/07, SS 2007

– Course on "*Quantum field theory I*", Berlin, October 2006-February 2007

– Course on "*Introduction to the standard model*", Berlin, October 2006-February 2007

– Course on "*Quantum field theory II*", Berlin, April-July 2007

– Course on "*Functional integration and lattice field theory*", Berlin, April-July 2007

– "*Lectures on Lattice Field Theory*", 26 March - 1 April, 2007, Florianopolis, Brazil

– "*Lectures on Lattice Field Theory*", Minischool on Lattice QCD, April 16-20 2007, TianJin, China

– Course on "*Introduction to lattice QCD*", within the INT Summer School on "*Lattice QCD and its applications*", Seattle, August 2007

1.11.3 VISIT of SENIOR SCIENTISTS from OUTSIDE the NETWORK

– Herbert Neuberger, Rutgers University, USA, visiting Berlin Jul 2006 – Dec 2006 and Jun 2007 – Jul 2007

– R.P. Springer, Duke University, USA, visiting Bonn 26.08.07-09.09.07

– B.L. Ioffe, ITEP Moscow, Ru, visiting Bonn 15.05.07-31.05.07

– D. Lee, Raleigh, NC, USA, visiting Bonn 03.07.07-05.08.07

1.11.4 ORGANIZED SCHOOLS

– 24th Students' Workshop on Electromagnetic Interactions, Bosen (Saar), 9-14 September 2007

– INT Summerschool "Lattice QCD and its applications", August 8- Aug. 28, 2007, Seattle, USA
Participation of 40 students.

– Workshop on Lattice QCD, Chiral Perturbation Theory and Hadron Phenomenology , Trento, Italy, 2-6 October 2006
36 Participants

1.11.5 GENERAL TRAINING

– Computational Physics (Programming in matlab), Berlin, April-July 2007

– German for foreigners, DESY, October 2006 - July 2007

– English Conversation, DESY, October 2006 - July 2007

– Guidance in Scientific Research in Quantum field theory and Elementary Particle Physics, Münster, October 2006 - July 2007

1.11.6 PERIODS SPENT my MEMBERS of the FLAVIANET in OTHER NODES/SUBNODES

– 29/5/07 – 31/5/07 Training on HQET by Rainer Sommer at Tor Vergata, Rome (Node 5)

YEAR 2

1.11.7 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

1.11.8 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

1.11.9 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

1.11.10 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

1.11.11 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

1.11.12 ESR HIRED

– Francesco Virotta, hired in DESY in April 2008, ESR 21 months contract

– Michael Donnellan, hired in DESY in July 2008, ESR 27 months contract

1.11.13 ESR PERSONAL CAREER DEVELOPMENT PLAN TUTORING, ADVISING, OPPORTUNITIES

– Francesco Virotta

Francesco Virotta 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 Virotta 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 Virotta 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 apropriate 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 dstribution 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 $B \to \pi\, l\, \nu$ for the precision extraction of V_{ub} or $B \to D\, l\, \nu$ 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 aquire 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 apropriate 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 aquired knowledge in a broad range of aspects of lattice gauge theory. He will thus qualify as an experienced postdoc in the field.

YEAR 3

1.11.14 OFFERED PH. COURSES (LOCALLY)

Listing all courses takes too much space. We list courses at Berlin (where the ESR's are located) and Münster as an example. A similar program was available at the Universities of Mainz and Bonn.

- Course on *Physik moderner Teilchenbeschleuniger*, Berlin, Oct 2008 - Feb 2009
- Course on *Quantum Field theory and String Theory*, Berlin, Oct 2008 - Feb 2009
- Course on *Introduction to Cosmology*, Berlin, Oct 2008 - Feb 2009
- Course on *Introduction to Supersymmetry*, Berlin, Oct 2008 - Feb 2009
- Course on *Lattice Gauge Theory*, Berlin, Oct 2008 - Feb 2009
- Course on *Physics at LHC*, Berlin, Oct 2008 - Feb 2009
- Course on *General Relativity*, Berlin, Oct 2008 - Feb 2009
- Course on *Introduction into the Standard Model*, Berlin, Oct 2008 - Feb 2009
- Course on *Astro Particle Physics*, Berlin, Oct 2008 - Feb 2009
- Course on *Introduction to Quantum field theory* Berlin, Apr 2009 - Jul 2009
- Course on *Introduction to String Theory* Berlin, Apr 2009 - Jul 2009
- Course on *Advanced Computational Physics* Berlin, Apr 2009 - Jul 2009
- Course on *Experimental Particle Physics* Berlin, Apr 2009 - Jul 2009
- Ph. D. Tutorial on "*Spontaneous Symmetry Breaking*" Berlin, Apr 2009 - Jul 2009
- Ph. D. course on *Advanced Topics in Quantum Chromodynamics*, Münster, Oct 2008 - Feb 2009
- Ph. D. and Research Seminar on *Quantum Field Theory*, Münster, Oct 2008 - Feb 2009 and Apr 2009 - Jul 2009
- Ph. D. and Student Tutorial on *Theoretical Nuclear and Particle Physics*, Münster, Oct 2008 - Feb 2009 and Apr 2009 - Jul 2009

1.11.15 OFFERED COURSES at ANY LEVEL of interest for the FLAVIANET

- Course on ”Introduction to Quantum Field Theory”, Muenster, April 2009 - July 2009
- Student Seminar on ”Cosmology and Particle Physics”, Muenster, October 2008 - February 2009
- Student Seminar on ”Selected Topics in Quantum Mechanics”, Muenster, April 2009 - July 2009

1.11.16 VISIT of SENIOR SCIENTISTS from OUTSIDE the NETWORK

- Various visits of senior scientists.

1.11.17 ORGANIZED SCHOOLS

- *Modern perspectives in lattice QCD* summer school, 3-28 Aug 2009, Les Houches, France. Organizers: L. Lellouch (node 8), R. Sommer (node 11), B. Svetitsky (Tel Aviv), A. Vladikas (node 5)

The purpose of the School was to impart a deeper theoretical understanding of lattice QCD as well as to survey new, powerful computational methods. Our principal aim was to bring a new generation of young theorists into contact with leading experts in these fields. Important theoretical methods, including chiral lattice fermions, heavy quark effective theories, and chiral perturbation theory were taught alongside computational strategies, algorithms, and the relevance of lattice QCD to high energy experiments.

Flavianet members teaching: P. Hernandez (node 1), L. Lellouch (node 8), M. Lüscher (node 9), O. Philipsen (node 11), S. Schäfer (node 11), R. Sommer (node 11), A. Vladikas (node 5), P. Weisz (node 4)

Flavianet members attending: D. Baumgartner (node 9), F. Bernardoni (node 1), M. Brambilla (node 5), S. Dinter (node 11), S. Di Vita (node 5), X. Feng (node 11), J. Frison (node 8), P. Fritzsch (node 3), D. Hesse (node 11), L. Keegan (node 3), E. Kerrane (node 3), J. Langelage (node 11), L. Orifici (node 5), A. Portelli (node 8), A. Ramos (ER, node 8), F. Virotta (node 11), G. Vulvert (node 8)

Participation of others: a total of 55 Ph.D. students and young postdoctoral fellows attended the schools and 4 additional leading scientists in the field were called upon to lecture (S. Aoki (Tsukuba), T. Appelquist (Yale), M. Golterman (San Francisco), D. Kaplan (U. of Washington))

1.11.18 GENERAL TRAINING

- Computational Physics (Programming in matlab), Berlin, Oct 2008 - Feb 2009 and Apr 2009 - Jul 2009
- Course: *German Language Course*, Berlin, 2008/2009

1.11.19 ESR HIRED

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

1.11.20 ESR CAREER DEVELOPMENT PLAN, TUTORING, ADVISING, OPPORTUNITIES

- Name of fellow: Francesco Virotta
- Workplace: DESY, Zeuthen, Germany .
- Name of Supervisor: Dr. Rainer Sommer.

BRIEF OVERVIEW OF RESEARCH PROJECT AND MAJOR ACCOMPLISHMENTS EXPECTED My current research project is on algorithms for lattice QCD simulations. It started out as an investigation to the possibility of extending the current DD-HMC algorithm to include the heavier quark flavours (strange and charm). This has then shifted to adress the severe critical slowing down of topological modes, a relevant topic in modern lattice simulations that most urgently needs a solution. This problem partly affects current simulations and in case it won't be promptly cured, we expect it to be one of the main obstacles in the direction toward the continuum limit. Possible modifications of the DD-HMC algorithm that could solve the problem are currently under investigation. I'm also continuing the study of general aspect of lattice QCD, by attending the summer scool in Les Houches and courses at Humboldt University of Berlin.

LONG-TERM CAREER OBJECTIVES (over 5 years)

1. Goals: I intend to keep studying possible improvements to current simulation techniques, in particular I would like to learn about reweighting techniques currently developed at the CERN FLAVIAnet node. I will also put my effort in calculating physical quantities and improving current results and practices, also by means of the newly developed simulations techniques.

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

To gain a better understanding of current simulation techniques further studies in the literature are needed. Collaboration with others members of Flavianet could also help my

understanding of the main current issues that need to be adressed in the near future of lattice simulations.

SHORT-TERM OBJECTIVES (1-2 years)

1. Research results/Anticipated publications: In collaboration with Dr. Stefan Schaefer from Humboldt University we have investigated the critical slowing down of lattice simulations towards the continuum limit. In particular we have investigated the severeness of the problem in the range of lattice spacings used in contemporary simulations and proposed a method to give more reliable error estimates. This study was presented at the XXVII International Symposium on Lattice Field Theory. It is published as a proceedings contribution and a detailed publication in a journal is in preparation.

2. Research Skills and techniques:

I deepened my knowledge of programming tecniques and advanced error analysis. In this regard I modified the existing DD-HMC code to suit our needs for the critical slowing down analysis and developed some numerical error analysis software in MATLAB. I also deepened my understanding of high performance computing by running (and partly updating) some code for performance analysis on the cluster of HLRN and on some prototype INTEL machines. Discussions with Dr. M. Donnellan and Dr. H. Simma (DESY researcher and permanent staff member) were helpful in this regard.

3. Research management:

AFS disk space management for the research group. Help in organizing the SFB Meeting of March 2009 held in DESY-Zeuthen.

4. Communication skills:

I will be giving a talk at the FLAVIAnet meeting in Southampton in December. I have also given three exercise sessions at the lectures on lattice QCD held by Dr. R. Sommer at Humboldt University.

5. Other professional training

I have taken a German course at the Goethe Institut in Berlin and I keep studying German following internal courses organized at DESY.

6. Anticipated networking opportunities:

Attending the FLAVIAnet meeting Euroflavour 2009. When appropriate will be visiting other nodes such as the swiss node.

1.11.21 ESR CAREER DEVELOPMENT PLAN, TUTORING, ADVISING, OPPORTUNITIES

- Name of fellow: Michael Donnellan
- Workplace: DESY, Zeuthen, Germany .
- Name of Supervisor: Dr. Rainer Sommer.

BRIEF OVERVIEW OF RESEARCH PROJECT AND MAJOR ACCOMPLISHMENTS EXPECTED I continue to be involved in projects such as the meson distribution amplitude calculations that I started during my PhD studies in Southampton, but am now concentrating on the two main branches of my research at DESY Zeuthen: the study of lattice QCD simulation algorithms and the running of the simulations, and phenomenology projects using non-perturbative HQET.

LONG-TERM CAREER OBJECTIVES (over 5 years)

1. Goals: I intend to maintain my interest in the development of simulation techniques and to contribute to progress in that area, but to focus on the extraction of quantities relevant to flavour physics from lattice QCD.

2. What further research activity or other training is needed to attain these goals? To achieve these goals, it will be important to gain a deeper understanding of the variety of approaches taken to studying heavy quarks on the lattice, and in particular the non-perturbative matching of HQET using the Schroedinger functional.

SHORT-TERM OBJECTIVES (1-2 years)

1. Research results/Anticipated publications: I have now invested a lot of effort in learning about the current simulation algorithms, and have gained substantial experience both in the ordinary running of the simulations as well as in diagnosing and investigating associated problems. A couple of minor technical issues remain to be solved but, in addition to the continued management of the current simulations I expect to be involved in publications relating to the progress of the simulation programme (in particular, in relation to a number of high statistics runs that I have been responsible for, and which are intended for studies of the mixing properties of the Markov chain algorithm).

I have also written a new parallel program for the measurement of HQET 2-point correlation functions, including 1/M corrections, using all-to-all propagators. As well as using this program to efficiently perform the standard measurements for the HQET programme, I intend to conduct a study of variance reduction methods for these quantities and also to extend it for calculations of the $B^*B\pi$ coupling, which is a crucial non-perturbative input for the heavy meson chiral Lagrangian, and also for the calculation of B meson semileptonic form factors, which are essential for the extraction of CKM matrix elements from experimental data.

2. Research Skills and techniques: In order to make progress with my simulation-related research, I have had to deepen and broaden my knowledge and understanding of high-performance computing. For example, I have attended courses at the Juelich Supercomputing Centre on the specific systems which I use there, as well as courses on tuning and performance organised by the North-German Supercomputing Alliance. I have acquired experience with a broad range of debugging and profiling tools. This experience has been relevant to the development of my HQET measurement programs. For those I also had to

deepen my understanding of C and learn data parallel programming with MPI. All of this will be essential to efficiently achieving the objectives described above.

3. Research management: I have assisted in organizing the SFB Meeting of March 2009 held in DESY-Zeuthen. I have also been involved in the preparation of applications for supercomputing resources at the Juelich Supercomputing Centre and at the Zuse Institut in Berlin.

4. Communication skills: I have given talks both at FLAVIAnet meetings and internally at DESY, and will be speaking at a FLAVIAnet meeting in Southampton in December. In addition, I have recently taken over the organisation of the joint DESY Zeuthen - Humboldt University lattice seminar series.

5. Other professional training As already mentioned, I have taken a number of courses related to high performance computing, and it is likely that I will attend others should relevant courses by offered. I have taken one German course at the Goethe Institut and intend to attend another course at a higher level held at DESY.

6. Anticipated networking opportunities: I will be attending FLAVIAnet meetings such as Euroflavour 2009, and when appropriate visiting other nodes such as Mainz (having already visited our collaborators there once in December 2008).

YEAR 4

1.11.22 OFFERED PhD COURSES (LOCALLY)

Listing all courses would take up too much space. We list courses at Berlin (where the ESR's are located) and, as an example, Münster. A similar program was available at the Universities of Mainz and Bonn.

- Advanced seminar on *Heavy Quark Effective Theory I*, Berlin, Oct 2009 - Feb 2010
- Advanced seminar on *Heavy Quark Effective Theory II*, Berlin, Apr 2010 - Jul 2010
- Ph. D. course on *General Relativity*, Münster, October 2009 - February 2010
- Ph. D. course on *Quantum Field Theory and QCD*, Münster, April 2010 - July 2010
- Ph. D. and Research Seminar on *Quantum Field Theory*, Münster, October 2009 - February 2010 and April 2010 - July 2010
- Ph. D. and Student Tutorial on *Theoretical Nuclear and Particle Physics*, Münster, October 2009 - February 2010 and April 2010 - July 2010

1.11.23 OFFERED COURSES at ANY LEVEL of interest for the FLAVIANET

- Course on *Computational Physics II*, Berlin, Oct 2009 - Feb 2010
- Course on *Quantum Field Theory II*, Berlin, Oct 2009 - Feb 2010

– Course on *General Relativity*, Berlin, Oct 2009 - Feb 2010
– Course on *Introduction into the Standard Model*, Berlin, Oct 2009 - Feb 2010
– Course on *Hochleistungsrechnen für Naturwissenschaftler*, Berlin, Oct 2009 - Feb 2010
– Course on *Quantum Field Theory I*, Berlin, Apr 2010 - Jul 2010
– Course on *Lattice Quantum Field Theory*, Berlin, Apr 2010 - Jul 2010
– Course on *Flavour Physics*, Berlin, Apr 2010 - Jul 2010
– Course on *Introduction to Quantum Field Theory*, Münster, April 2010 - July 2010
– Student Seminar on *Phase Transitions and Critical Phenomena*, Münster, October 2009 - February 2010
– Student Seminar on *Path Integrals in Quantum Mechanics and Field Theory*, Münster, April 2010 - July 2010
– Course on *"Theoretical Hadron Physics"*, Bonn, October 2009–February 2010
– Course on *"Quantum Chromodynamics"*, Bonn, October 2009–February 2010
– Seminar on *"Topological Effects in Quantum Field Theory"*, Bonn, October 2009–February 2010
– Course on *"Quantum Field Theory"*, Bonn, April–July 2010
– Course on *"Advanced Theoretical Hadron Physics"*, Bonn, April–July 2010

1.11.24 VISIT of SENIOR SCIENTISTS from OUTSIDE the NETWORK

– Many senior scientists have been visiting Berlin.
– Bin-Song Zou, Beijing, China, visiting Bonn January 10–16 2010
– Dean Lee, Raleigh, NC, USA, visiting Bonn June 19–July 10 2010

1.11.25 ORGANIZED SCHOOLS

– Hadron Physics Summer School, Bad Honnef, August 9–13 2010, participation of ca. 60 students Flavianet Members participating: Bastian Kubis (lectures), Akaki Rusetsky (working group organization) Participation of others: PhD students Daniela Tolentino, Phillip Hagen, David Minossi (all Bonn)

1.11.26 GENERAL TRAINING

– Course: *German Language Course*, Berlin, 2009/2010

1.11.27 ESR HIRED

- Francesco Virotta, hired in DESY in April 2008, ESR, 21 month contract
- Michael Donnellan, hired in DESY in July 2008, ESR, 27 month contract

1.11.28 ESR CAREER DEVELOPMENT PLAN, TUTORING, ADVISING, OPPORTUNITIES

- Name of fellow: Francesco Virotta
- Workplace: DESY, Zeuthen, Germany .
- Name of Supervisor: Dr. Rainer Sommer.

BRIEF OVERVIEW OF RESEARCH PROJECT AND MAJOR ACCOMPLISHMENTS EXPECTED My PhD research project is on algorithms for lattice QCD simulations. It started out as an investigation of the possibility of extending the current DD-HMC algorithm to include the heavier quark flavours (strange and charm). It then shifted to address the severe critical slowing down of topological modes, a highly relevant topic which has arisen in modern lattice simulations and which urgently requires a solution. This problem affects current simulations and if it is not promptly cured, we expect it to be one of the main obstacles to approaching the continuum limit. I am currently investigating the properties of the so-called Wilson flow in dynamical simulations in collaboration with the Mainz subnode. In particular, this will provide a way to obtain the ratio of lattice spacings for different lattices with a greatly improved precision compared to what has been possible so far. As a result the removal of lattice artefacts by numerical extrapolation of the data will become much easier.

LONG-TERM CAREER OBJECTIVES (over 5 years)

1. Goals: I intend to continue studying possible improvements to current simulation techniques. In particular I would like to learn about the reweighting techniques currently being developed at the CERN FLAVIAnet node. I will also contribute to calculations of physics observables and to the improvement of current results and techniques.

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

I need to obtain a deeper understanding and overview of current simulation techniques from systematic studies of the literature. Discussions with other lattice gauge theorists during my involvement in Flavianet and with those of the lattice community in Berlin will hopefully produce new ideas for the redesign of the algorithms.

SHORT-TERM OBJECTIVES (1-2 years)

1. Research results/Anticipated publications: In collaboration with Dr. Stefan Schaefer

of the Humboldt University I have investigated the critical slowing down of lattice simulations as they approach the continuum limit. In particular we have investigated the severity of the problem in the range of lattice spacings used in contemporary simulations and proposed a method to give more reliable error estimates. This study was presented at the XXVII International Symposium on Lattice Field Theory and has been published as a proceedings contribution. A detailed publication has been submitted to the Nuclear Physics B journal. An update of the results including a study of how the critical slowing down affects other observables of physical interest in current simulations has been presented by me at the XXVIII International Symposium on Lattice Field Theory. A further publication will result from the study of the Wilson flow and the associated scale setting.

2. Research Skills and techniques:

I have deepened my knowledge of programming tecniques and advanced error analysis. In this regard I have modified the existing DD-HMC code to suit our needs for the critical slowing down analysis and have developed some numerical error analysis software in MATLAB. I have also deepened my understanding of high performance computing by running (and partly updating) some code for performance analysis on the HLRN cluster and on some prototype Intel machines. Discussions with Dr. M. Donnellan and Dr. H. Simma (DESY researcher and permanent staff member) were helpful in this regard. I am currently developing a software for the integration of the wilson flow, based partly on the lattice simulation software for the domain decomposed hybrid Monte Carlo (publicly available on the web).

3. Research management:

AFS disk space management for the research group. Help in organizing the SFB Meeting of March 2009 held in DESY-Zeuthen.

4. Communication skills:

I have given talks at: SFB Meeting in Berlin in March 2009. FLAVIAnet meeting in Southampton in December 2009. XXVIII international symposium on lattice field theory (June 2010). I attended the FLAVIAnet meeting Euroflavour 2009 and Euroflavour 2010. I visited the Mainz subnode for a collaboration meeting in March 2010.

I also taught three exercise sessions at the lectures on lattice QCD held by Dr. R. Sommer at Humboldt University.

5. Other professional training

I have taken a German course at the Goethe Institut in Berlin and I continue to study German by following courses organized internally at DESY.

6. Anticipated networking opportunities:

I will be travelling to the node of Karlsruhe for the SFB Meeting of December 2010.

1.11.29 ESR CAREER DEVELOPMENT PLAN, TUTORING, ADVISING, OPPORTUNITIES

- Name of fellow: Michael Donnellan
- Workplace: DESY, Zeuthen, Germany .
- Name of Supervisor: Dr. Rainer Sommer.

BRIEF OVERVIEW OF RESEARCH PROJECT AND MAJOR ACCOMPLISHMENTS EXPECTED I continue to be involved in projects such as the meson distribution amplitude calculations that I started during my PhD studies in Southampton, but am now concentrating on the two main branches of my research at DESY Zeuthen: the study of lattice QCD simulation algorithms and the running of the simulations, and phenomenology projects using non-perturbative HQET.

LONG-TERM CAREER OBJECTIVES (over 5 years)

1. Goals: I intend to maintain my interest in the development of simulation techniques and to contribute to progress in that area, but to focus on the extraction of quantities relevant to flavour physics from lattice QCD.

2. What further research activity or other training is needed to attain these goals? To achieve these goals, it will be important to gain a deeper understanding of the variety of approaches taken to studying heavy quarks on the lattice, and in particular the non-perturbative matching of HQET using the Schroedinger functional.

SHORT-TERM OBJECTIVES (1-2 years)

1. Research results/Anticipated publications: A publication on the ALPHA Collaboration determination of the static quark-antiquark potential with 2 flavours of dynamical quarks, to which I have been contributing, is almost finished and a preprint should be available this month. In addition, a paper presenting the most recent results of the UKQCD/RBC light meson distribution amplitudes project, in which I continue to be involved, will be published on a similar timescale.

I have invested a lot of effort in learning about the current simulation algorithms, and have gained substantial experience both in the ordinary running of the simulations as well as in diagnosing and investigating associated problems. In addition to the continued management of the current simulations, there remain both technical and algorithmic issues related to the gauge configuration generation in which I am interested and plan to contribute to in the months ahead. For example, it would be beneficial to have a multithreaded version of the production code with hybrid MPI/OpenMP parallelization.

I have written a parallel program for the measurement of HQET 2-point correlation functions, including 1/M corrections, using all-to-all light-quark propagators. This program is being used to efficiently perform the standard measurements for the HQET programme,

which will lead to publications on heavy-light meson spectroscopy and decay constants next year. I have also conducted a study of variance reduction methods for these and other quantities in collaboration with Rainer Sommer and John Bulava which will eventually be published, and plan to further investigate such methods.

I have extended the HQET measurement code for static calculations of the $B^*B\pi$ coupling, which is a crucial non-perturbative input for the heavy meson chiral Lagrangian. This project has produced results in both the quenched and two-flavour cases which improve considerably upon those previously available, and which should both be published in the next few months. I intend very soon to extend this code also to the calculation of B meson semileptonic form factors, which are essential for the extraction of CKM matrix elements from experimental data.

2. Research Skills and techniques: In order to make progress with my simulation-related research, I have had to deepen and broaden my knowledge and understanding of high-performance computing. For example, I have attended courses at the Juelich Supercomputing Centre on the specific systems which I use there, as well as courses on tuning and performance organised by the North-German Supercomputing Alliance. I have acquired experience with a broad range of debugging and profiling tools. This experience has been relevant to the development of my HQET measurement programs. For those I also had to deepen my understanding of C and learn data parallel programming with MPI. All of this will be essential to efficiently achieving the objectives described above. In addition, I have attended a course on GPU Programming in Juelich, and am interested in investigating the possibility of adapting some of the simulation and measurement programs to such systems.

3. Research management: I have assisted in organizing the SFB Meeting of March 2009 held in DESY-Zeuthen. I have also been involved in the preparation of applications for supercomputing resources at the Juelich Supercomputing Centre and at the Zuse Institut in Berlin.

4. Communication skills: I have given several talks at FLAVIAnet meetings, at ALPHA Collaboration meetings, at the International Lattice Conference, and internally at DESY Zeuthen. I shall be giving a talk at a meeting of the research network Sonderforschungsbereich/Transregio 9 in December. In addition, I have been responsible for the organisation of the joint DESY Zeuthen - Humboldt University lattice seminar series for over a year now and will continue to be responsible for that during the current semester.

5. Other professional training As already mentioned, I have taken a number of courses related to high performance computing, and it is likely that I will attend others should relevant courses be offered. I have taken one German course at the Goethe Institut and intend to attend another course at a higher level held at DESY.

6. Anticipated networking opportunities: I will be visiting Karlsruhe for the Sonderforschungsbereich/Transregio 9 meeting in December and will be visiting Collaborators in, for example, Mainz and CERN as and when appropriate.

2 Outreach

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 FLAVIA*net* 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 FLAVIA*net* network, either during FLAVIA*net* events or between nodes of the network. A first step has consisted in setting up a web page on the FLAVIA*net* 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.
At the beginning of July 2009 the Swiss team (node 9) held the conference Chiral Dynamics at the University of Bern, and had about 160 participants, gathering many participants of the network. The opening lecture was given by Nobel laureate Steven Weinberg who is recognized as one of the founding fathers of the field which plays a prominent role in the Flavianet activities. Steven Weinberg also gave a public lecture on "Cosmic dark matter". The lecture has been widely publicized in the city of Bern and was also one of the activities celebrating the 175. years of the University of Bern. About 600 people came to the lecture (about half of them in the lecture hall where Weinberg was speaking and the other half in a second lecture hall where we had set up a live video transmission).

2.2 Science week and open days

All the nodes of the FLAVIA*net* network take part in national Science weeks or European events or national cycles of conferences to popularise science. 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 2009 Science Week (19-26 September 2009), the Frascati laboratories was open to the general public members of FLAVIA*net* 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 and Marseille 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.

- On March 14. 2009, the University of Bern presented itself to the public during the so-called "Fakultätstag" (day of the faculties). Particle physics (theoretical as well as experimental) was involved heavily. Members of node 9 had two tables showing experiments and computer calculations and large posters illustrating our activities. In addition four short lectures were given on particle physics

- On April 19th 2010, the Frascati laboratory (node 5) was open to the general public members of FLAVIA*net* belonging to the KLOE experiment, have guided visitors through the laboratories to explain the goals and methods of research in particle physics. They also took part in the European Researcher's night (Sep 24th 2010).

- Node 9 started a new series of lectures for the general public in Bern, under the name *Einstein lectures*, since Einstein did some of his most important discoveries when he was in Bern around 1905. The first speaker of the series was the Nobel Prize Prof. Franck Wilczek (MIT) with three lectures ("What is space?", Nov 30th 2009, "Majorana returns", Dec 1st 2009, "Anticipating a new golden age", Dec 2nd 2009)

- Members of the FLAVIA*net* network in Orsay (node 8) 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, we mention three initiatives:

- 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. Two different shows, called "Dinosaurs from Dust - The World's Most Powerful Particle Smasher" and "3D LHC", are currently touring over Britain 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.

- The IFIC group (node 1) organized a vast photographic exhibition on the LHC, which toured over fourteen Spanish towns from August 2009 to July 2010. This open exhibition took place in major streets, squares or parks, attracting in this way the interest of a very large portion of the population. Special activities addressed to more specific audiences have been organized in parallel.

- During the international ICHEP conference taking place in Paris in July 2010, the French team (node 8) organised "The night of the particles" in a famous cinema theatre in the centre of Paris. This event featured a conference on the physics of the infinitely small and infinitely large, an interview of several scientists, a short film by the French actress Irène Jacob, and a mainstream movie ("Sunshine"). The event, advertised nationally, attracted several hundreds of attendants.

The Nobel Prize in Physics 2008 was deeply related to the different areas covered by the network, which gave the opportunity for researches of FLAVIA*net* to promote their field of research for

high schools, museums or cultural centres: J. Soto (Simetries subtilment trencades) [node 2] U. Nierste(Vom Weltall zur Weltformel: R??sel der modernen Physik) [node 4], J. Bijnens (On the connection between magnets, the Higgs particle and a V.I.P. party, and The Nobel Prize in Physics 2008: Broken Symmetries) and J. Eeg (Symmetrier som brytes - Nobelprisen 2008) [node 7], S. Descotes-Genon (A la poursuite de l'antimatiere) [node 8].
Other topics were also covered in talks for general audiences, in connection with LHC Physics: Q. Matias (L'Energia Fosca de l'Univers: L'ultima frontera) and R. Escribano (The LHC: the last frontier of particle physics) [node 2], P.J. Edwards (LHC talks) [node 3], L. Lellouch (L'infiniment petit révélé par les superordinateurs) [node 8], Helmut Neufeld (What is Particle Physics ?) [node 10].
There are also more local initiatives, for instance:

- The UK teams (node 3) have involed 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.

- On six Saturdays, members of node 9 invite high-school students from the Canton of Bern and neighbouring regions to lectures about physics called Physics am Samstag. The aim is to give them an opportunity to learn what kind of research in Physics is carried out at the University of Bern and to get information on studying here. The node coordinator (G. Colangelo) is also the organizer of this activity. Two of the six lectures were dedicated to particle physics, one experimental and one theoretical.

- Coordinated by the institutional delegation of CSIC in the Comunidad Valenciana, members of the Valencia team (node 1) have participated in the outreach programme "con Ciencia Sé". This a series of guided visits to the research institutes of CSIC in the Comunidad Valenciana, in particular to IFIC, which is addressed to students of the secondary school. It includes a short introductory talk on particle physics, and a visit to the experimental laboratories.

- Members of node 8 wrote and coordinated a two-face book on "The physics of the two infinities", published by a well-known French science editor. This book highlights the growing connections between particle physics and astrophysics. The public is both school pupils and their teachers, with an ambitious programme of conferences and pedogogical activities in order to invite and helpt school teachers to use this book as a basis of their teaching of physics.

3 Conclusions

The FLAVIA*net* network has offered 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 FLAVIA*net*

young researchers. The network has constituted 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. The network has also implemented in its program adequate outreach activities. This network has become 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 have been 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 FLAVIA*net* has contributed 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 and continuing those offered at the level of this network.