Training Activity

CONTRACT NO. 35482

01/10/2009 — 30/09/2010

We report on the fourth year 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 01/10/2009–30/09/2010.
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 Meeting held at the Technical University in Munich in September 2010 (and detailed in the FLAVIA*net* Research Report), the Annual European Flavour Physics School and several Research Training Workshops (detailed in the FLAVIA*net* Research Report).
The annual Flavianet school 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.
We can state that inside the FLAVIA*net* the young researchers have accessed a lively, cutting-edge scientific frame and countless concrete opportunities to interact with the best European ad

International experts in Flavour Physics. Besides this, as it is apparent from this report, we have taken the appropriate care to train our researchers in several complimentary 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 (ESR) and the Experienced Researchers (ER) 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. 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 during the last year. 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]

1.1.1 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.

1.1.2 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.

1.1.3 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.

1.1.4 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.

1.1.5 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

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

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

1.1.7 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-Barcelona (Univ. Autònoma de Barcelona, Univ. de Barcelona, Univ. Politècnica, Univ. de Granada and Univ. de Huelva)

1.2.1 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).

1.2.2 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.

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

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

1.2.4 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. No. 3: U.K.

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 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).

1.3.2 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)

1.3.3 GENERAL TRAINING

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

1.3.4 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

1.3.5 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 3rd 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 23rd 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 [arXiv:1007.2378 [hep-ph]].

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 (Karlsruhe Institute of Technology)

1.4.1 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

1.4.2 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*

1.4.3 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

1.4.4 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.

1.4.5 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.

1.4.6 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])

1.5.1 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.

1.5.2 OFFERED COURSES at ANY LEVEL of interest for the FLAVIANET

- 2010 LNF Spring Institute: Frontiers of Strong Interactions, LNF, Spring 2010 [http://www.lnf.infn.it/the

1.5.3 VISIT of SENIOR SCIENTISTS from OUTSIDE the NETWORK

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

1.5.4 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.

1.5.5 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 4 October 2009-September 2010

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.

- *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

1.6.2 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

1.6.3 VISIT of SENIOR SCIENTISTS from OUTSIDE the NETWORK

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

1.6.4 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

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

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

1.6.6 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.

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

1.7 Node No. 3. Nordic (Lund University, University of Oslo and Helsinki Insitute of Physics.

1.7.1 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.

1.7.2 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.

1.7.3 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

1.7.4 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

1.7.5 GENERAL TRAINING

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

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

- Ilaria Jemos, October 1 2007- September 30 2010

1.7.7 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)

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 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)

1.8.2 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)

1.8.3 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.

1.8.4 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).

1.8.5 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.

1.8.6 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.

1.8.7 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)

1.8.8 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

1.8.9 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 precission 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 Cor-

rections 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))

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 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.

1.9.2 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 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

1.9.4 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.

1.9.5 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)

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: 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

1.10.2 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

1.10.3 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

1.10.4 GENERAL TRAINING

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

1.10.5 ESR

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

1.10.6 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

1.11.1 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

1.11.2 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

1.11.3 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

1.11.4 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)

1.11.5 GENERAL TRAINING

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

1.11.6 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

1.11.7 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.

1.11.8 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 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 Science week, open days and activities for the general public

All the nodes of the FLAVIA*net* network take part in national Science weeks, 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:

- 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.

2.2 School-oriented activities

Beside these events, long-run programs of visits for school pupils are organised in several of the nodes of the network, often relying on an on-line booking through a web interface in order to provide an easy access for interested teachers. Such initiatives take place for instance at the IFIC center (Valencia, node 1), the ACO accelerator in relation with the LAL laboratory (Orsay, node 8), the Desy-Zeuthen centre and the Humboldt university (Berlin, node 11)... Another successful program consists in Masterclasses, one-day events mixing lectures, exercises and visits for

pupils and (sometimes) teachers. Such events are regularly organised in Durham, Oxford and Southampton (node 3), at the University of Silesia (Katowice, node 6), the LAL laboratory (node 8), the University of Vienna (node 10), the Desy-Zeuthen centre and the Humboldt university (Berlin, node 11) as well as the University of Münster (node 11), attracting hundreds of pupils. There are also 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.

2.3 Outreach infrastructures

In addition to the outreach page of the FLAVIA*net* website, several nodes have contributed to web pages on particle physics in local languages, for instance Barcelona (node 2), Oslo (node 7), Orsay (node 8), Vienna (node 10). Some of the nodes have developed specific infrastructures, on which they can rely for their outreach activities:

- The involvement of IFIC (node 1) in Outreach activities enabled to develop a Scientific Outreach Office, which is used in all CSIC institutes in the Valencia Region and which will be extended to other Spanish provinces.

- The IPPP in Durham (node 3) has a Science and Society officer, developping several family shows explaining the science behind the LHC, coordinating the outreach activities towards schools, organising exhibitions linking physics and arts...
- Lund (node 7) has a "National resource centre for physics", which is a national resource organisation to help physics teachers at schools.
- The LAL laboratory (node 8) owns an exhibition room dedicated to particle physics, with a bubble chamber showing tracks of particles from cosmic rays as they go through the detector and a cosmic arch detecting cosmic rays.
- Desy-Zeuthen (node 11) has set up a lab room for high-school students to perform experiments with a visit of about 2500 students per year.

The existence of such dedicated centres, as well as the large variety of outreach activities inside the nodes of the network, shows how lively and significant outreach activities are inside FLAVIA*net* . Let us mention that the contacts established inside the research and training environment of the FLAVIA*net* can also help to improve the outreach skills of the various nodes : ideas and material for exhibitions and conferences can easily be shared between members of the network, in the margin of network meetings conferences or inter-node visits.

3 Conclusions

The FLAVIA*net* network has offered a first level training in Flavor Physics, theory and experiments, and in 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. 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. Furthermore 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. The network has also implemented in its program adequate outreach activities.