# Training Activity

CONTRACT NO. 35482

01/10/2008 — 30/09/2009

We report on the third 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 (U. Milano).
In the following we report the training and TOK achievements for each of the eleven FLAVIA*net* nodes in the period 01/10/2008–30/09/2009.
At this point all the Early Stage Researchers (ESR) and Experienced Researchers (ER) contracts have started or have been committed.
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 IPPP in Durham in September 2008 (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 Karlsruhe, Germany, from Sep 7 to 18, 2009. This year school put the emphasis on short-distance aspects of flavour physics, such as electroweak decays and rare processes sensitive to new physics. Twelve scientists from Europe and the USA taught 37 hours of lectures, which were complemented by 10 tutorial session devoted to the discussion of the homework assignments. The school was attended by 60 participants, 27 of which were from Karlsruhe, 24 were affiliated with other Flavianet institutions and 9 were enrolled in universities outside Flavianet. Among the 24 external Flavianet participants were 4 current or former Flavianet ESR: Pablo Roig (node 8), Ilaria Jemos (node 7), Miguel Escobedo (node 5) and Pere Masjuan (node 10). As a novel feature, we have included a business partner in the organisation of the school, the company <phi–t>, which is a spin-off from an experimental flavour physics group in Karlsruhe. <phi–t> has financially supported the school and its CEO, Prof. Michael Feindt, has given a lecture on *Artificial intelligence for flavour physics and economy*. Further events of the school were a poster session, at which the participants could present their thesis topics and scientific results to each other, and a guided tour of the experimental facilities at the Karlsruhe Research Center (Northern Campus of the Karlsruhe Institute of Technology). The latter include the KATRIN experiment, devoted to the measurement of the neutrino mass.

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, 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.
Although the rate of employing young researchers was initially slower than what was foreseen in the contract, the hiring situation looks quite well at present. A total of 4 ER and 23 ESR young researchers have been already recruited for a total of 481 person-months (96 ER months and 385 ESR months). Two additional ESR contracts are already committed for a total of 15 months. Therefore, only 8 ESR months are still available. No problems are foreseen to fill these few remaining open positions.

# 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)

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

- Ph.D. course on "Quantum Field Theory", Valencia, September – November 2008.
- Ph.D. course on "Advanced Quantum Field Theory", Valencia, November 2008 – January 2009.
- Ph.D. course on "Quantum Chromodynamics", Valencia, November 2008 – January 2009.
- Ph.D. course on "Electroweak interactions", Valencia, November 2008 – January 2009.
- Ph.D. course on "Experimental Nuclear Physics", Valencia, November 2008 – January 2009.

- Ph.D. course on “High Energy Physics”, Valencia, January – March 2009.
- Ph.D. course on “Non-perturbative methods”, Valencia, January – March 2009.
- Ph.D. course on “Advanced Phenomenology”, Valencia, January – March 2009.

### 1.1.2 OFFERED COURSES at ANY LEVEL of interest for the FLAVIANET

- A. Pich, “Field Theory and the Standard Model”
  International Summer School and Conference on High Energy Physics: Standard Model and Beyond (ISSCSMB’09), Muğla, Akyaka, Turkey, 27 August – 4 September 2009.
- A. Pich, “Chiral Perturbation Theory”
  Flavianet School on Flavour Physics, Universität Karlsruhe, Karlsruhe, Germany, 7–18 September 2009.
- P. Hernández, “Lattice QCD Fundamentals”
  *Modern perspectives in lattice QCD: Quantum field theory and high performance computing*, Les Houches Summer School, Les Houches, France, 3–28 August 2009.
- P. Hernández, “Neutrino Physics”
  *V CERN Latin Americal School of High Energy Physics* Recinto Quirama, Colombia, March 2009.

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

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

### 1.1.4 VISIT of SENIOR SCIENTISTS from OUTSIDE the NETWORK

- Dr. Francisco V. Flores-Baez, *CINVESTAV*, Mexico, Mexico, to IFIC (Valencia) in December 2008.
- Dr. Juan Rojo, *INFN*, Milan, Italy to IFIC (Valencia) in December 2008.
- Dr. Jan Winter, *Fermi National Laboratory*, USA to IFIC (Valencia) in January 2009.
- Dr. H.Q. Zheng, *Beijing University*, Beijing, China, to IFIC (Valencia) in February 2009.

- Dr. Jan Winter, *Fermi National Laboratory*, USA to IFIC (Valencia) in May 2009.
- Dr. Tanju Gleisberg, *SLAC*, USA to IFIC (Valencia) in May 2009.
- Dr. Sven Heinemeyer, *IFCA*, Santander, Spain to IFIC (Valencia) in May 2009.
- Dr. Andreas Nyffeler, *Harish-Chandra Research Institute*, Allahabad, India, to IFIC (Valencia) in June 2009.

#### 1.1.5 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 already selected and committed (their contract will start next year)

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

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

**LONG-TERM CAREER OBJECTIVES (over 5 years)**

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

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

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

**SHORT-TERM OBJECTIVES (1-2 years)**

1. Research results/Anticipated publications:

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

2. Research Skills and techniques:

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

3. Research management:

We plan to involve Emilie in the organization of some FLAVIA*net* events. She will also participate in the FLAVIA*net* working groups. In addition, Emilie will have the possibility to acquire a basic

knowledge of how an European Contract is administered and dealt with, and will get familiar with the relevant information about applications for research grants and postdoctoral fellowships.
4. Communication skills:
The FLAVIA*net* general meetings constitute an ideal environment to discuss the new results, getting feed-back from the scientific community and improving at the same time the communication skills of the ER/ESR fellows. Emilie has already presented results in past EuroFlavour Conferences. Her new achievements will be presented at the next EuroFlavour09 Conference in Bari.
5. Other professional training
At IFIC, Emilie will have the possibility to profit from a very extensive programme of seminars and colloquia in various aspects of particle physics, from cosmology to condensed matter.
1. Anticipated networking opportunities:
FLAVIA*net* will allow Emilie to perform research visits and short stays in several nodes with common interests and keep a very active scientific collaboration with them. We could certainly anticipate a very strong relation with the French and Swiss nodes.
2. Other activities (community, etc) with professional relevance:
Emilie is expected to follow some language courses to learn Spanish.

## 1.2 Node No. 2: Spain-Barcelona (Barcelona-Granada-Huelva)

### 1.2.1 OFFERED PH. COURSES (LOCALLY)

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

### 1.2.2 OFFERED COURSES at ANY LEVEL of interest for the FLAVIANET

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

### 1.2.3 ORGANIZED SCHOOLS

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

### 1.2.4 GENERAL TRAINING

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

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

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

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

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

- Clark Downum

### 1.2.7 ESR PERSONAL CAREER DEVELOPMENT PLAN TUTORING, ADVISING, OPPORTUNITIES

- Name: Zhi-Hui Guo

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

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

**BRIEF OVERVIEW OF RESEARCH PROJECT AND MAJOR ACCOMPLISHMENTS EXPECTED** In the low-energy regime, the perturbative Quantum Chromodynamics (QCD) breaks down. However, in the massless limit, the chiral invariant $(u, d, s)$ light-quark interaction becomes spontaneously broken, generating a set of (pseudo) Goldstone bosons which can be identified with the lightest multiplet of pseudoscalar mesons. Their dynamics can be then described at soft momentum and small quark masses by means of an effective field theory (EFT) based on chiral symmetry, chiral perturbation theory ($\chi$PT).
This EFT stops being valid when the energy reaches the first resonances. One needs then to employ alternative methods for the description of the observables (e.g. the $\pi\pi$–scattering) in this range, like, for instance, unitarization methods, resonance lagrangians... Nevertheless, it is important that the extended description still recovers the right long-distance limit prescribed by $\chi$PT.
In the present era of high-precision measurements, it is becoming crucial to have better and better determinations of the standard model parameters. Eventually, this may allow the observation of new physics in observables such as the muon anomalous magnetic moment or $K_{\ell 3}$ decays, where a sizable part of the uncertainties have hadronic origin.
In a first stage of the project, the fellow plans to apply the various chiral descriptions for strong interactions to processes which are already pretty well under control both from the experimental

and theoretical side. This, in addition to increase the precision of currently known parameters, will allow to refine the description of resonance and chiral Goldstone interactions. In a second step of the project, this will be applied to the search of small deviations from the standard model, once the theoretical hadronical uncertainties have been reduced to a marginal level.
Likewise, in parallel to his work in QCD, the fellow is carrying on a project on physics beyond the standard model. In collaboration with researchers from other groups, the fellow is studying some aspects of several Randall-Sundrum scenarios that could show up in the forthcoming LHC experiment.
In his stay at Granada Univ., the fellow will work on two long term projects which will improve his knowledge and skillness on non-perturbative QCD. The first one is a complete study of the scalar form factor of the three light quarks (u, d and s) within an unitarized non-perturbative chiral approach. This study will be done in the combined limits of the light quarks masses going to zero and large number of QCD colors ($N_c$). The applications of this study are several: computation of light quark masses, scalar matrix elements, computation of $p^4$ $\chi$PT couplings among others. The second project the fellow will develop in his stay at Granada is the calculation of the lowest order coupling constants describing the rare kaon decays $K \to \pi e^+ e^-$ at next-to-leading in a $1/N_c$ expansion. These rare kaon decays are quite important for elucidating the type of new physics beyond the Standard Model. They are complementary studies to direct searches that will be performed at LHC shortly.

**LONG-TERM CAREER OBJECTIVES (over 5 years)**

1. Goals: During his Ph.D. the fellow studied the essential effective field theory and quantum field theory techniques, and their applications to the description of the hadronic interaction in the non-perturbative (low-energy) range of QCD. Thus, nowadays, new accurate and precise determinations of the standard model parameters are leading to very stringent tests on possible new physics.
Many of these techniques will be likely needed if LHC finds new states or strongly interacting regimes at high energies. The fellow, then, plans in the long term to progressively focus his attention in topics beyond the standard model like, for instance, extra dimensions.
2. What further research activity or other training is needed to attain these goals?
In order to achieve his goals, it is essential that the fellow collaborates with experts in those fields and attends conferences and workshops related to the topics of his interest.

**SHORT-TERM OBJECTIVES (1-2 years)**

1. Research results/Anticipated publications: The fellow plans to publish an average of two or three papers per year.
2. Research Skills and techniques:
They will continue to improve through everyday's research work and collaboration with more senior members.
3. Research management:
None.
4. Communication skills:

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

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

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

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

### 1.2.8 ESR PERSONAL CAREER DEVELOPMENT PLAN TUTORING, ADVISING, OPPORTUNITIES

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

**BRIEF OVERVIEW OF RESEARCH PROJECT AND MAJOR ACCOMPLISHMENTS EXPECTED** Recently experimental studies of $e^+e^-$ collisions at energies of $\approx$ 4-4.5 GeV have indicated a variety of states which are not expected from the traditional quark model. There are numerous competing models of these states, including a molecular model where each new state is a bound molecule of two known mesons. Studies of molecular models suggest that they can describe these newly discovered anomalous states. However, they are very sensitive to poorly determined or arbitrary parameters. This research project seeks to use the results of Lattice QCD to constrain the parameters of molecular models. Using the lattice, it may be possible to constrain the parameters of the molecular models well enough to discriminate between them and other models of these anomalous states. These results would also have broader implications for using Lattice QCD as input for the strong hadron-hadron interaction. The fellow expects to conduct research in collaboration with colleagues at UB. The research will be prepared, with the assistance of collaborators, for publication in peer-reviewed journals. Additionally, talks at conferences or seminar presentations on the results of this work are anticipated.

**LONG-TERM CAREER OBJECTIVES (over 5 years)**

1. Goals:

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

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

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

**SHORT-TERM OBJECTIVES (1-2 years)**

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

2. Research Skills and techniques:

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

3. Research management:

None.

4. Communication skills:

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

5. Other professional training

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

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

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

### 1.2.9 ESR PERSONAL CAREER DEVELOPMENT PLAN TUTORING, ADVISING, OPPORTUNITIES

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

**BRIEF OVERVIEW OF RESEARCH PROJECT AND MAJOR ACCOMPLISHMENTS EXPECTED** The effective field theory vNRQCD allows to describe among others the production of top-antitop pairs in electron-positron collisions at threshold, i.e. with very small relative velocity $v \ll 1$ of the quarks. Potentially large logarithms $\propto \ln v$ are systematically summed up and lead to a scale dependence of the Wilson coefficients of the theory.

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

**LONG-TERM CAREER OBJECTIVES (over 5 years)**

1. Goals:

The PhD work of the fellow was concerned with the theoretical prediction of the cross section $\sigma(e^+e^- \to t\,\bar{t})$ focusing on the contributions from the (ultrasoft) renormalization group running of the quark-antiquark potentials and including a two-loop calculation of the latter. One long-term goal is to pursue this line of research and use his results also in other calculations as e.g. the bottom quark mass determination from non-relativistic $\Upsilon$ sum rules.
Another aim is to extend his expertise to other frameworks to describe the non-relativistic regime of heavy quark systems, in particular pNRQCD, in order to reveal the relations on the level of specific calculations between the different theories in detail. This might help to find a framework which combines the advantages and reduces the technical and conceptual deficiencies of both approaches to a minimum. The study of the QCD static potential in pNRQCD as well as in vNRQCD, as mentioned above, will be one project in that context.
More generally the fellow aims to gain more understanding of the non-perturbative effects in heavy quark systems with the help of effective field theories of the strong interactions as well as to use his experience in multi-loop calculations, in particular renormalization, in high-energy collider physics.

2. What further research activity or other training is needed to attain these goals?
To attain this goal it is necessary that the fellow collaborates with experts in those fields and attends conferences and workshops related to the topics of his interest.

**SHORT-TERM OBJECTIVES (1-2 years)**

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

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

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

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

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

## 1.3 Node No. 3: United Kingdom

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

- Ph.D Course on “Overview of Particle Physics”, Durham, October-May 08/09
- Ph.D Course on “Introductory Field Theory”, Durham, October-May 08/09
- Ph.D Course on “Group Theory”, Durham, October-May 08/09
- Ph.D Course on “Symmetries”, Southampton, October-May 08/09
- Ph.D Course on “Standard Model”, Durham, October-May 08/09
- Ph.D Course on “Standard Model”, Southampton, October-May 08/09

- Ph.D Course on “General Relativity”, Durham, October-May 08/09
- Ph.D Course on “Quantum Electrodynamics”, Durham, October-May 08/09
- Ph.D Course on “Quantum Field Theory”, Durham, October-May 08/09
- Ph.D Course on “Quantum Field Theory”, Southampton, October-May 08/09
- Ph.D Course on “Conformal Field Theory”, Durham, October-May 08/09
- Ph.D Course on “Conformal Field Theory”, Southampton, October-May 08/09
- Ph.D Course on “Lattice Field Theory”, Southampton, October-May 08/09
- Ph.D Course on “Supersymmetry”, Durham, October-May 08/09
- Ph.D Course on “Supersymmetry”, Southampton, October-May 08/09
- Ph.D Course on “Anomalies”, Durham, October-May 08/09
- Ph.D Course on “Strong Interaction Physics”, Durham, October-May 08/09
- Ph.D Course on “Cosmology”, Durham, October-May 08/09
- Ph.D Course on “Cosmology”, Southampton, October-May 08/09
- Ph.D Course on “Superstrings and D-Branes”, Durham, October-May 08/09
- Ph.D Course on “Strings and Brane Theory”, Southampton, October-May 08/09
- Ph.D Course on “Non-perturbative Physics”, Durham, October-May 08/09
- Ph.D Course on “Euclidean Field Theory”, Durham, October-May 08/09
- Ph.D Course on “Effective Field Theory and Flavour Physics”, Durham, October-May 08/09
- Ph.D Course on “Particle Phenomenology”, Southampton, October-May 08/09
- Ph.D Course on “Neutrinos and Astroparticle Physics”, Durham, October-May 08/09
- Ph.D Course on “Integrability in Quantum Theory”, Durham, October-May 08/09
- Ph.D Course on “Introduction to AdS/CFT”, Durham, October-May 08/09
- Ph.D Course on “Extra dimensions in gravity”, Durham, October-May 08/09
- Ph.D Course on “Computing for Physicists”, Durham, October-May 08/09
- Ph.D Course on “MHV-rules, recursion relations and unitarity”, Durham, October-May 08/09

- Ph.D Course on “Experimental techniques”, Durham, October-May 08/09
- Ph.D Course on “Simulations in high energy physics”, Durham, October-May 06/07 & 07/08y

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

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

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

### 1.3.2 ORGANIZED SCHOOLS

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

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

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

  Higgs-Maxwell Meeting, Edinburgh, 4 February 2009

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

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

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

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

### 1.3.3 GENERAL TRAINING

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

- Colloquia in Durham, Oxford and Southampton, several times per month.

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

- Patrick Frtizsch, hired in Southampton, 24 month contract

- Stefano Nicotri, hired in Durham, 12 month contract

## 1.5 ESR PERSONAL CAREER DEVELOPMENT PLAN TUTORING, ADVISING, OPPORTUNITIES

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

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

  **Training, research project and major accomplishments**

  Right after participating in the Mid-Term Review of FLAVIA*net* at Durham University in 2008, Patrick Fritzsch moved from Münster (node Germany-North) to his new position at the University of Southampton (UK node). While continuing his former work on a non-perturbative treatment of Heavy Quark Effective Theory (HQET), he started his training in Southampton on non-perturbative renormalization in the MOM scheme, the use of chiral perturbation theory in lattice QCD applications and an introduction to the domain wall fermion (DWF) discretization. 2+1 dynamical fermion configurations of the latter are used by the local group as member of the RBC/UKQCD collaboration to compute, for instance, the $B_K$ parameter and to study decays like $K \to \pi \ell \nu$, which are relevant for a precision extraction of certain parameters of the CKM matrix. Within this collaboration Patrick Fritzsch also acquired detailed knowledge about the Relativistic Heavy Quark action (RHQ) as developed by Norman Christ (Columbia University, USA) and about CPS, the Columbia Physics System, to compute appropriate matrix elements involving heavy quarks on the lattice.

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

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

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

**Short-term objectives**

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

**Long-term career objectives (next 5 years)**

Patrick Fritzsch also wants to work in the future on heavy quark phenomenology, especially using non-perturbative methods like the lattice discretization. He profits from the expertise offered by various experts of different FLAVIA*net* nodes. It allows him to work in various sub-collaborations applying different tools to reach this goal. A possible application of the acquired methods during his FLAVIA*net* position is the combination of the SF and DWF for instance. He wants to deepen his current research with those experts as well as starting new collaborative efforts on topics in high energy physics with other researchers of the field, especially some he met at the summer school in Les Houches.

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

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

**Brief overview of activities**

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

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

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

**Long-term career objectives**

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

He has had the opportunity to apply for a one-year Research Associate position within the Institute for Particle Physics Phenomenology of Durham University. The application has been successful and he will spend the next year at the Institute, at the end of his ESR contract. Then, he plans to continue his academic career, obtaining a postdoctoral position from another European research institute, possibly in Italy, though he is open to new experiences in some non-academic environments.

**Short-term objectives**

Stefano has produced the three scientific papers describing his results. His short-term research goals are the study of chiral symmetry breaking and axial mesons, the study of

the $U(1)_A$ problem and the investigation of the properties of Wilson loops and heavy-quark potentials in holographic models of QCD.

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

### 1.6.1 OFFERED PH. COURSES (LOCALLY)

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

- *Collective Quantum Phenomena: Laser, Superconductivity etc.* (W. Kilian, Siegen, Oct 2008 - Feb 2009)

- *Special Topics in Quantum Field Theory* (T. Mannel, A. Khodjamirian, Siegen, Oct 2008 - Feb. 2009)

- *Special Topics in Quantum Field Theory* (A. Khodjamirian, Siegen, Apr. 2009 - Jul. 2009)

### 1.6.2 OFFERED COURSES at ANY LEVEL of interest for the FLAVIANET

- *Ringberg Workshop on New Physics, Flavors and Jets*, Apr 26 – May 1st 2009

- Workshop on "Progress and Challenges in Flavour Physics", Primosten (Croatia), September 29-October 3 2009, organized by the Unversity of Siegen and the Rudjer Boskovic Institute, Zagreb (Croatia)

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

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

### 1.6.4 VISIT of SENIOR SCIENTISTS from OUTSIDE the NETWORK

- Prof. Dr. Ikaros Bigi, *Univ. Notre Dame*, USA, to TU Munich, June – November 2008

- Dr. A. A. Pivovarov, *INR Moscow*, to Univ. Siegen, May 2009 to July 2009.

- Dr. Chris Quigg, *Fermilab*, Batavia, USA, to Univ. Karlsruhe, October – November 2008 and March – May 2009

- Dr. Chris Quigg, *Fermilab*, Batavia, USA, to TU Munich, October – December 2009

- Prof. Dr. Frank Wilczek, *MIT*, Cambridge, USA, to Univ. Karlsruhe, December 2009.

### 1.6.5 ORGANIZED SCHOOLS

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

  Flavianet Members participating:

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

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

### 1.6.6 GENERAL TRAINING

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

### 1.6.7 ESR HIRED

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

### 1.6.8 ER HIRED

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

### 1.6.9 ESR PERSONAL CAREER DEVELOPMENT PLAN TUTORING, ADVISING, OPPORTUNITIES

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

**BRIEF OVERVIEW OF RESEARCH PROJECT AND MAJOR ACCOMPLISHMENTS EXPECTED**

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

**LONG-TERM CAREER OBJECTIVES (over 5 years)**

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

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

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

**SHORT-TERM OBJECTIVES (1-2 years)**

1. Research results/Anticipated publications: Two loop corrections to soft functions in event shape distributions. Chiral corrections to meson decay constants.

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

3. Research management: No management duties.

Fellowship or other funding applications planned (indicate name of award if known; include fellowships with entire funding periods, grants written/applied for/received, professional society presentation awards or travel awards, etc.): Extension of current funding from MPI.

4. Communication skills: Steady improvement through scientific talks.

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

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

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

### 1.6.10 ER CAREER DEVELOPMENT PLAN, TUTORING, ADVISING, OPPORTUNITIES

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

**BRIEF OVERVIEW OF RESEARCH PROJECT AND MAJOR ACCOMPLISHMENTS EXPECTED:**

The analysis of the $B_s$-$\overline{B}_s$ system in the Standard Model is currently in its final stage. Currently a large experimental effort is devoted to the measurement of the width difference among the two mass eigenstates. Further experiments start to constrain the complex CP-violating phase in the $B_s$-$\overline{B}_s$ system through bounds on the semi-leptonic CP asymmetry. Both quantities involve the off-diagonal element $\Gamma_{12}$ of the decay matrix. The theoretical prediction of this quantity is obtained through the Heavy Quark Expansion (HQE), which involves the two expansion parameters $\alpha_s$ and $\Lambda_{\rm QCD}/m_b$. Currently $\Gamma_{12}$ is known to first oder in both expansion parameters. We are computing the corrections proportional to the product of the two expansion parameters. This calculation will stabilize and improve the theoretical prediction and is necessary for theory to keep up with the accuracy of the future LHCb experiment. The result will have several other applications: One can use it to update the mixing-induced CP asymmetry in the inclusive $b \to u\overline{u}d$ transitions. More importantly, one can link $\Gamma_{12}$ to branching ratios into double-charm final states of $B_d$ mesons. These branching ratios are currently measured at the B factories BaBar and BELLE.

The calculation is difficult and cumbersome, but the ER profits from the experience of his supervisor with the previous calculation of the $\alpha_s$ corrections. It is planned to publish the result soon.

**LONG-TERM CAREER OBJECTIVES (over 5 years):**

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

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

The calculation of higher order QCD corrections is a difficult task and requires the collaborative work of several experienced people. In addition to the ER and his supervisor, another postdoc, Dr. Marchetti, has joined the project. Dr. Marchetti is paid from national sources. The ER already has a solid record of calculations of higher-order QCD corrections. As for the required training, the ER is currently learning how to renormalize the four-quark operators involved in the calculation and how to factorize infrared effects from his supervisor.

**SHORT-TERM OBJECTIVES (1-2 years):**

1. Research results: Anticipated publications: One publication soon.

Anticipated conference, workshop attendance, courses, and /or seminar presentations: Participation on conferences and meeting conducted by Flavianet, seminars within the university and

other conferences and workshops are envisaged, once results are obtained. Further the ER plans to give seminars at other institutions within Flavianet, as a contribution to the networking activity.
2. Research Skills and techniques: Training in specific new areas, or technical expertise etc: The ER is well-trained in his field. He will deepen his knowledge on the renormalisation of the effective field theories used in B physics.
3. Research management: Fellowship or other funding applications planned (indicate name of award if known; include fellowships with entire funding periods, grants written/applied for/received, professional society presentation awards or travel awards, etc.) The ER's salary from 1/10/2007 to 30/9/2009 is funded from the Research and Training Network Flavianet (MRTN-CT-2006-035482). The project further requires computing power, which is provided by the host, the TTP. The ER has his own PC with the necessary computer algebra software. The ER's work contract in Karlsruhe has been extended by two months with funding from national sources.
4. Communication skills: The Institut für Theoretische Teilchenphysik (TTP) organises several weekly internal seminars, where the fellow will practice and improve his skills in scientific presentations. Further he will give talks at physics conferences.
5. Other professional training (course work, teaching activity): We have decided not to involve Dr. Hovhannisyan in teaching activities, because our legal department told us that we will risk to receive reduced funding from the EU, if the ER spends part of his work time on teaching.
6. Anticipated networking opportunities: The ER will attend the relevant topical meetings even after the completion of his ER appointment.
7. Other activities (community, etc) with professional relevance: none

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

### 1.7.1 OFFERED PH. COURSES (LOCALLY)

- Ph. D. Course on "*The Standard Model*", joint course of Rome-1 and Rome-3 Universities, Winter 2009.

- Ph. D. Course on "*Experimental Particle Physics*", joint course of Rome-1 and Rome-3 Universities, Winter 2009.

- Ph. D. Course on "*Flavour Physics*", Pisa University, Spring 2009.

- Ph. D. Course on "*Heavy Flavour Physics*", University of Naples, Spring 2009.

### 1.7.2 OFFERED COURSES at ANY LEVEL of interest for the FLAVIANET

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

### 1.7.3 VISIT of SENIOR SCIENTISTS from OUTSIDE the NETWORK

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

### 1.7.4 ORGANIZED SCHOOLS

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

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

### 1.7.5 GENERAL TRAINING

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

### 1.7.6 ESR HIRED (October1, 2008.September 30, 2009)

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

### 1.7.7 ESR PERSONAL CAREER DEVELOPMENT PLAN TUTORING, ADVISING, OPPORTUNITIES

- Name: Pablo Roig Garcés
- Department: Physik Department, Technical University Munich
- Name of the supervisors: Nora Brambilla and Antonio Vairo

**Brief overview of research project and major accomplishments expected** The research plan is to study heavy quarkonium physics, in particular radiative decays of the lowest-lying states, using effective field theories (EFT) like non-relativistic QCD (NRQCD) and potential NRQCD (pNRQCD). In addition to the intrinsic interest of describing the radiative decay of the J/$\Psi$ into $\eta_c\gamma$, we expect that our study will shed some light into the discrepancies found in measuring the mass of the $\eta_c$ meson when comparing the values coming from radiative decays of other quarkonium states to the results obtained from $\gamma\gamma$ or $p\overline{p}$ experiments. As noted in (arXiv:0805.0252) the $\eta_c$ mass is sensitive to the parameterization used for the lineshape. A

description as close as possible to the fundamental interaction occurring in Nature is desirable.

Our plan is to use EFT, in particular following the work done by Antonio Vairo, Nora Brambilla and Yu Jia (hep-ph/0512369) that studies the magnetic dipole transitions in quarkonium within this framework, in order to calculate the decay width including the effects of the fragmentation contributions- that happen to be important at low photon energies- making as less assumptions as possible, so that the result can be checked with experiments -and in particular, with CLEO data (arXiv:0805.0252)-.

## Long-term career objectives (over 5 years)

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

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

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

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

The group of Nora Brambilla and Antonio Vairo in Munich has offered to the fellow a perfect environment where to improve his knowledge and expertise in effective field theories. For this

reason the department of physics of the Technical University of Munich has been a very suitable place for the fellow to start the abovesaid complex problem in heavy quarkonium Physics. Moreover, this Department has also extremely strong research groups in Flavor Physics (also beyond the SM) and Neutrino Physics. The many seminars held in the Department have helped the fellow to complete his formation in this areas as well.

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

**Short-term objectives**

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

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

  Anticipated publications: Those related to the ones mentioned above.

- Research skills and techniques:

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

- Research management:

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

- Communication skills:

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

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

  During his stay in Munich the fellow has attended several seminars and colloquia in particle, nuclear and neutrino physics. All this in addition to the lectures listed in the item 'Research skills and techniques'. Although the fellow could not speak German fluently,

which made hard him teaching, Antonio Vairo let him teach five hours of his course on EFT, that was taught in English. Even though he has already taught for two years at his home University, it is important for the fellow to have had a first experience teaching in a non-mother tongue language. Another relevant aspect of his specific training was his participation in the School on EFT organized by the network and held in Karlsruhe last September.

- Anticipated networking opportunities:

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

### 1.7.8 ESR PERSONAL CAREER DEVELOPMENT PLAN TUTORING, ADVISING, OPPORTUNITIES

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

**Brief overview of research project and major accomplishment expected** The research project aims at a non-perturbative computation of renormalization of fermionic operators in lattice QCD (LQCD) with unquenched $u$, $d$, $s$ and $c$ quark flavours. This computation is a key step for a first-principle determination of quark masses and several matrix elements of phenomenological interest, such as those relevant for the weak effective Hamiltonian or the moments of hadron structure functions.
For this purpose we plan to employ the gauge ensembles that have been (and are being) produced by the European Twisted Mass (ETM) Collaboration. This collaboration has developed a convenient framework for studying QCD at non-perturbative level by means of efficient simulation algorithms (see Comput. Phys. Commun. **174** (2006) 87; PoS **LAT2005** (2006) 103) and a lattice regularization of the theory based on maximal twisted mass (Mtm) Wilson fermions (see JHEP **0108** (2001) 058, JHEP **0408** (2004) 007, JHEP **0410** (2004) 070). In this way discretization errors linear in the lattice spacing are elegantly and effectively removed, while the bare quark mass parameter that controls the pion mass provides a robust infrared cutoff for all numerical computations.
In the last years the MtmLQCD framework has been successfully employed to study the theory with two ($u$ and $d$) dynamical flavours: a number of physical observables were computed at several different lattice spacings, $m_{u/d}$-values and volumes, thereby allowing to make contact with the physical situation and obtain physics results for e.g. quark masses (from $m_{u/d}$ to $m_b$), pseudoscalar meson decay constants (from $f_\pi$ to $f_B$), meson and baryon spectrum, electromagnetic

hadron form factors, kaon-antikaon oscillations, $\pi$–$\pi$ scattering lengths and a few low energy constants of the QCD chiral effective Lagrangian (among which the chiral condensate).
Recently simulations of MtmLQCD with dynamical $u$, $d$ (degenerate) as well as $s$ and $c$ (non-degenerate) quarks (so called $n_f = 2 + 1 + 1$ setup) have been performed, based on the lattice fermionic formulation of Nucl. Phys. Proc. Suppl. **128** (2004) 193 and a suitable (Iwasaki) pure gauge action. While preliminary results appear to have good quality (see PoS **LAT2008** (2008) 094), much in line with those obtained with only two dynamical flavours, and further simulations on fine lattices are in progress, a special effort is required to obtain non-perturbative renormalization constants. Indeed, since the scheme where it is convenient to compute the running of the renormalization constants is a "mass-independent" one (in the sense of Phys. Rev. D **8**, 3497 (1973)), namely the RI'mom scheme (see e.g. refs. Nucl. Phys. B **445** (1995) 81; Nucl. Phys. B **531** (1998) 641; JHEP **0408** (2004) 022), the unquenched simulations with heavy $c$, "light-ish" $s$ and light $u$ and $d$ sea quarks, from which the non-renormalized and/or bare quantities are computed, can not be immediately used for the evaluation of the renormalization constants of the operators with non-vanishing anomalous dimension. Rather one has to perform, for each of the considered lattice resolutions, further dedicated simulations, now with $n_f = 4$ degenerate sea quarks at a few different, not too large (and for lattice-technical reasons not too small) mass values. On the resulting gauge configurations one can then compute the Landau gauge correlators that yield, after a suitable analysis (including a safe extrapolation to the zero-mass point), the desired renormalization constants in RI'mom scheme (see e.g. refs. JHEP **0408** (2004) 022 or PoS **LAT2007** (2007) 241).
Our plan amounts precisely to perform such renormalization dedicated simulations, starting from the largest lattice resolution among those studied by the ETM Collaboration in the $n_f = 2+1+1$ setup. Thanks also to the fellow's PhD work, the Monte Carlo code has been successfully tested and several exploratory simulations have already been performed in order to establish the (good) performance of the algorithm as well as the values of the bare mass parameters ($a\mu_{\rm sea}$, $m_{0,\rm sea} \equiv 1/(2\kappa_{\rm sea}) - 4$) at which it is convenient to simulate. This preliminary study allowed to formulate a detailed strategy for the numerical work, which has been started using BlueGeneP (see http://www.idris.fr/eng/Resources/index-babel.html) and MareNostrum (see http://www.bsc.es) supercomputers.
Off-line with respect to the simulations needed to produce $n_f = 4$ gauge ensembles, by using codes already available, the ETM Collaboration is computing the Landau gauge correlators from which the RI'mom renormalization constants will be eventually extracted. An important part of the work, in which the Roman branch of the collaboration has gained a lot of experience in previous quenched and $n_f = 2$ unquenched studies, is precisely the analysis of these Landau gauge correlators. The analysis includes several standard but non-trivial steps: subtraction, wherever needed, of Goldstone pole hadronic contaminations, chiral extrapolation, study of the renormalization scale dependence with the help of (N)NNLO perturbative anomalous dimension. The fellow is expected to significantly contribute to this task too.

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

- twisted mass Wilson fermions and unquenched Monte Carlo simulations; related publications: Physics Letters **B 650** (2007) 304–311; Comput. Phys. Commun. **179** (2008) 695;

- RI'mom scheme and non-perturbative renormalization in LQCD; related publication: JHEP **0804** (2008) 020;

- MtmLQCD with four dynamical quarks; see publication PoS **LAT2008** (2008) 094;

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

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

**Short-term objectives**

- Research result:

  Anticipated publications:

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

  Anticipated event attendance:

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

- Research skills and techniques:

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

- Research management:

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

- Communication skills:

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

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

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

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

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

## 1.8 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)

### 1.8.1 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.

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

### 1.8.2 OFFERED COURSES at ANY LEVEL of interest for the FLAVIANET

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

### 1.8.3 VISIT of SENIOR SCIENTISTS from OUTSIDE the NETWORK

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

### 1.8.4 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

### 1.8.5 ESR HIRED (October1, 2008.September 30, 2009)

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

### 1.8.6 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-$\phi$-peak data ($e^+e^-$ center-of-mass energy $\sqrt{s}=1$ GeV).
The two-photon form factors for pseudoscalar mesons $P=\pi,\eta,\eta'$ and scalar mesons $f_0(600)$, $f_0(980)$, $a_0(980)$ can be extracted from the $e^+e^-\to e^+e^-P$. It allows to study the $\gamma\gamma\to P\to\gamma\gamma$ contributions to the muon $g-2$ as well as the $P\to\gamma\gamma$ decays. The approach and tools for precise extraction of relevant form factors from the experimental data are to be worked out, implementing all necessary radiative corrections. The EKHARA generator for the reaction $e^+e^-\to e^+e^-\pi^+\pi^-$ developed in Katowice made a good starting point for these studies.
The theoretical tools for better understanding of photon-hadron interactions and use at meson factories are the major expected accomplishments. Hopefully they will assist a significant lowering of the theory error on light-by-light contributions to $g-2$ of the muon and the extraction of meson factors.

**LONG-TERM CAREER OBJECTIVES (over 5 years)**

1. Goals:

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

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

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

**SHORT-TERM OBJECTIVES (1-2 years)**

1. Research results/Anticipated publications:

Anticipated publications:

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

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

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

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

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

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

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

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

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

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

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

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

  *talk: “Radiative return: a progress on FSR tests”*

- Presentations at University of Silesia (host University) seminars

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

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

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

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

- Presentations at Universität Karlsruhe seminars

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

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

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

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

3. Research management:
Fellowship or other funding applications planned (indicate name of award if known; include fellowships with entire funding periods, grants written/applied for/received, professional society presentation awards or travel awards, etc.)
Application for Polish Ministry of Science and Higher Education grant with H. Czyż group (July 2009).
4. Communication skills:

- Language course
- Participation in local seminars at University of Silesia

- Preparing the academic papers.

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

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

Participation in scientific schools:

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

1. Anticipated networking opportunities:

- Discussions with F. Jegerlehner in Katowice.

Co-operation with the following groups:

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

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

### 1.8.7 PUBLICATIONS DURING THE FIRST 12 MONTHS OF 24

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

- S. Ivashyn and A. Korchin, "Interactions of light scalar mesons from the Resonance Chiral Theory,"
  in proceedings of "Trans-European School of High Energy Physics 2008," Buymerovka (Sumy region), Ukraine

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

### 1.9.1 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 2009.
- Ph. D. course on "*Relativistic Quantum Mechanics and introduction to Quantum Field Theory*", Lund, September-December 2008.
- Ph. D. Course "*Colours, flavours and their consequences*", Lund, October 2008-February 2009
- Advanced course on "*FYS4170 - Relativistic quantum field theory*", Oslo, August-November 2008.
- Ph. D. course on "*FYS9120 - Advanced quantum field theory*", Oslo, Jan-May 2009.
- Ph. D. course on "*QCD and hadron structure*", Helsinki, Sep-Dec 2008.

### 1.9.2 OFFERED COURSES at ANY LEVEL of interest for the FLAVIANET

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

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

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

### 1.9.4 VISIT of SENIOR SCIENTISTS from OUTSIDE the NETWORK

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

### 1.9.5 GENERAL TRAINING

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

### 1.9.6 ESR already selected and committed

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

### 1.9.7 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 2009 took place in February and early October. The present staus of her PhD studies are that the course work is finished up to completing a programming course. The research work is going as planned. One paper has been published and the work on a new fit of the LECs at NLO using all available NNLO information is progressing. We have also started a new project within hard pion ChPT. She has attended the Flavianet schools and meetings and two more conferences. We have discussed possible options for after obtaining the PhD. Her supervisor in Lund is Johan Bijnens with deputy supervisor Leif Lönnblad and experimental mentor in Frascati Erika De Lucia.

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

## 1.10 Node No. 8: France (CNRS)

### 1.10.1 OFFERED PH. COURSES (LOCALLY)

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

- Quantum Field Theory, second year Masters course (Oct 08-Jan 09, Orsay)
- Particles and symmetries, second year Masters course (Oct 08-Jan 09, Orsay)
- Introduction to cosmology, second year Masters course (Oct 08-Jan 09, Orsay)
- High-energy astrophysics, second year Masters course (Oct 08-Jan 09, Orsay)
- Weak interaction and unification, second year Masters course (Mar 09-Jun 09, Orsay)
- Strong interaction, second year Masters course (Mar 09-Jun 09, Orsay)
- Neutrinos, second year Masters course (Mar 09-Jun 09, Orsay)
- Relativity and gravitation, second year Masters course (Mar 09-Jun 09, Orsay)
- Relativistic quantum field theory, second year Masters course (L. Lellouch, Sep 08-Dec 08, Marseille)
- Advanced quantum field theory, second year Masters course (M. Knecht, Jan-Mar 09, Marseille)
- The standard model and beyond, second year Masters course (J. Charles, Jan-Mar 09, Marseille)
- Particle physics, second year Masters course (Sep 08-Dec 08, Marseille)
- Introduction to astroparticle physics and cosmology, second year Masters course (Sep 08-Dec 08, Marseille)
- Experimental particle physics, second year Masters course (Jan-Mar 09, Marseille)
- Experimental astroparticle physics, second year Masters course (Jan-Mar 09, Marseille)
- General relativity, second year Masters course (Jan-Mar 09, Marseille)
- Geometry and gauge theories, second year Masters course (Jan-Mar 09, Marseille)
- Observational cosmology, second year Masters course (Jan-Mar 09, Marseille)
- Advanced quantum mechanics, second year Masters course (Sep 08-Dec 08, Marseille)
- Statistical mechanics, second year Masters course (Sep 08-Dec 08, Marseille)
- Non-linear dynamics and chaos, second year Masters course (Sep 08-Dec 08, Marseille)

### 1.10.2 OFFERED COURSES at ANY LEVEL of interest for the FLAVIANET

- Experimental and theoretical particle physics, M1 and M2 courses, M.H. Schune (February 2009, Kiev, Ukraine)
- The Standard Model and beyond, PhD Trans-European School of High Energy Physics, S. Descotes-Genon (Jul 2009, Zakopane, Poland)
- Flavor physics, PhD Trans-European School of High Energy Physics, M.H. Schune (Jul 2009, Zakopane, Poland)
- Lattice flavor physics (L. Lellouch), as part of the Les Houches summer school *Modern perspectives in lattice QCD: Quantum field theory and high performance computing,* August 3–28 2009, Ecole de physique des Houches, France.

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

- 2 PhD students (A. Taydagunov and B. Malaescu) took part in the *Flavianet Summer School on Flavor Physics* (September 7-18 2009, Karlsruhe).
- 2 PhD students (E. Bazzali and G. Vulvert) and 1 ER (A. Ramos) from Marseille took part in the very educational *Colloquium in Memory of Jan Stern,* Paris, 2-3 Sep 2009.

### 1.10.4 VISIT of SENIOR SCIENTISTS from OUTSIDE the NETWORK

- Mikhail Shifman (Univ. of Minnesota, USA) has been staying at LPT Orsay since Spring 2008 under an International Chair of Research Blaise Pascal (French state chair). He gave an inaugural lecture on superconductivity and quark confinement in June 2008, and he gave six lectures on *the Polyakov model of confinement* for M2 students in October 2008.
- Stephen Sharpe (Univ. of Washington, USA) visited CPT Marseille from June 23 to July 22, 2008, as an invited professor of the Université de la Méditerranée. He gave three ninety-minute lectures on *Applications of chiral perturbation theory to lattice QCD* to 13 graduate students and postdoctoral fellows and 17 scientists from France, Germany and Spain.
- Rahul Sinha (Chennai, India) visited CPT Marseille from 31st August to September 2nd 2008, for collaboration and a seminar.
- Maarten Golterman (San Francisco) was invited by our node to contribute a five lecture course on “Chiral Perturbation Theory” at the les Houches summer school *Modern perspectives in lattice QCD: Quantum field theory and high performance computing,* August 3–28 2009, organized by the network.
- David Kaplan (Univ. of Washington, USA) was invited by our node to contribute a five lecture course on “Chiral Lattice Fermions” at the same school.

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

### 1.10.5 ORGANIZED SCHOOLS

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

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

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

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

  Coming from: Poland, Ukraine, Russia, Romania, Hungary, Czech Republic, France.

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

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

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

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

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

### 1.10.6 GENERAL TRAINING

- English and French language courses provided by CNRS (Orsay) and University Paris-Sud 11 (Oct 08-Jun 09)
- *French language course for foreign scientists*, courses provided by CNRS (Marseille), attended by ER A. Ramos (node 8) from 02/09-06/09, 3h/week.
- Access to "Formation permanente" courses offered by CNRS (Orsay, Marseille)
- Weekly seminars on particle physics from September to July in Orsay, Marseille and Prague
- Monthly seminars among PhD students from September to July in Orsay, Marseille.

### 1.10.7 ESR HIRED (October1, 2008.September 30, 2009)

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

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

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

### 1.10.9 ER HIRED (October1, 2008.September 30, 2009)

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

### 1.10.10 ESR PERSONAL CAREER DEVELOPMENT PLAN TUTORING, ADVISING, OPPORTUNITIES

- **Nils Offen, Orsay**

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

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

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

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

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

*Achievements*
Besides learning the basics of French via courses provided by CNRS, he has completed his PhD thesis *B-Zerfallsformfaktoren aus QCD-Summenregeln* (in German) which he defended successfully Jan 25 2008 at the University of Siegen. N. Offen has finished two projects under the title *Light-cone sum rules for $B \to \pi$ form factors revisited* [Duplancic et al., JHEP 0804:014,2008] and *Semileptonic charm decays D —¿ pi l nu(l) and D —¿ K l nu(l) from QCD Light-Cone Sum Rules* [Khodjamirian, arXiv:0907.2842]. He has completed a project with Dr. S. Descotes-Genon, leading to two publications *Three-particle contributions to the renormalisation of B-meson light-cone distribution amplitudes* [S. Descotes-Genon, N. Offen, JHEP 0905:091,2009] and *Renormalization of B-meson distribution amplitudes* [S. Descotes-Genon, N. Offen, arXiv:0904.4687].

- **Ruben Garcia-Martin, Orsay**
  R. Garcia-Martin has started hisone-year ESR contract in Orsay on Oct 1st 2008. His local advisor is Dr B. Moussallam, with further local guidance and help from Pr. H. Sazdjian and

Drs. V. Bernard and S. Friot. Experimental aspects of flavor physics are covered through discussions with A. Stocchi, M.H. Schune, P. Roudeau (LAL Orsay). As a member of the particle physics group of IPN Orsay, R. Garcia-Martin has the opportunity to take part in the regular discussions between theorists and experimentalists on the Orsay campus. If needed, further background on basic physics can be easily obtained through the courses and seminars provided by the Department of Physics and the laboratories on the campus of Orsay.

*Career Development Plan*
The research work of R. Garcia-Martin inside the Flavianet concerns pion polarizability and photo-photon collisions. This project is aimed at refining the comparisons concerning the pion polarizabilities between the predictions, which are in principle very accurate, based on chiral perturbation theory and the determinations based on experimental data and dispersion relations. The aim is a new determination which uses the high accuracy results from photon-photon scattering producing a pion pair or a kaon-antikaon pair obtained recently by the Belle collaboration, associated with an optimal use of dispersion relations.

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

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

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

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

### 1.10.11 ER CAREER DEVELOPMENT PLAN, TUTORING, ADVISING, OPPORTUNITIES

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

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

## Brief overview of research project and major accomplishments expected

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

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

In this context, has taken responsibility for a number of the team's projects. In particular, he is currently finalizing a study of the ratio $F_K/F_\pi$ in QCD with $N_f = 2 + 1$ flavors of sea quarks, based on a series of lattice calculations with three different lattice spacings, large volumes and a simulated pion mass reaching down to about 190 MeV. The results of this calculation allows a controlled test of the Cabibbo-Kobayashi-Maskawa (CKM) model for quark-flavor mixing at the per-mil level, when combined with experimental studies of leptonic pion and kaon decays, such as the 2006 measurement of $K^+ \to \mu^+\nu_\mu(\gamma)$ by KLOE. This work was presented by the fellow at the "XXVII International Symposium on Lattice Field Theory" (Lattice 2009) (to appear in the proceedings) and is also the subject of a paper which he is finalizing ("The ratio $F_K/F_\pi$ in QCD," Budapest-Marseille Wuppertal Collaboration, in preparation).

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

In the coming year, the fellow will also investigate the strange, scalar form factor of the nucleon at zero recoil. Not only is this quantity an important parameter in models of nucleons, but it also enters the cross-section of dark matter candidates with nuclei in many extensions of the standard

model. At present, our poor knowledge of this matrix element represents the leading theoretical uncertainty in the interpretation of direct detection experiments.

## Long-term career objectives (over 5 years)

- Goals:

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

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

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

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

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

## Short-term objectives (1-2 years)

- Research results/Anticipated publications:

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

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

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

- Research Skills and techniques:

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

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

- Research management:

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

- Communication skills:

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

- Other professional training:

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

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

- Anticipated networking opportunities:

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

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

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

## 1.11 Node No. 9: Switzerland (Universität Bern (UBERN))

### 1.11.1 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 2008/09 we had:

  "Basic Data Analysis", Stephan Durr (Jülich)

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

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

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

  "Renormalization Group", Peter Hasenfratz (Bern)

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

### 1.11.2 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.

### 1.11.3 VISIT of SENIOR SCIENTISTS from OUTSIDE the NETWORK

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

### 1.11.4 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.

### 1.11.5 ESR already selected and committed

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

### 1.11.6 ESR PERSONAL CAREER DEVELOPMENT PLAN TUTORING, ADVISING, OPPORTUNITIES

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

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

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

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

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

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

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

- **E. Passemar, ESR contract, Bern**
  At the end of her first year as ESR in Bern, Emilie Passemar has successfully completed and defended (with honours) her PhD thesis. She has continued her work inside the the Kaon Working group, and on the project in collaboration with G. Colangelo and Stefan Lanz on the dispersive treatment of $\eta \to 3\pi$. She has had regular discussions and exchanges also with other senior members of the node, like J. Gasser, and H. Leutwyler on different aspects related to her research activity. *Career Development Plan*
  After completing the PhD, Emilie Passemar has started a search for a new job. The search

has been very successful, as she quickly got an offer from the University of Valencia. She has also participated to the selection for the "qualification aux fonctions de maitre de conference" in France, which she obtained. This means that in the following four years whenever there is an opening at this level in a french university she can directly applied.

*Training and collaboration*
At the University of Bern she has attended graduate courses on "Basic Data Analysis", "Group Theory", "Introduction to Kaluza-Klein Theory", and "Renormalization Group" and finally a lecture by H. Leutwyler on "Looking back at 50 years of particle physics". She has also had german courses for beginners.

*Achievements*
E. Passemar has completed a new original article, has contributed to a long report on flavour physics in the quark sector (which will be published in Physics Report) and a conference proceedings. The latter will soon become an original article.

## 1.12 Node No. 10: Austria (Universität Wien)

### 1.12.1 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 2008, summer term 2009
- Seminar: Noncommutative Geometry and Strings, winter term 2008, summer term 2009

### 1.12.2 OFFERED COURSES at ANY LEVEL of interest for the FLAVIANET

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

### 1.12.3 VISIT of SENIOR SCIENTISTS from OUTSIDE the NETWORK

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

### 1.12.4 GENERAL TRAINING

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

### 1.12.5 ESR

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

### 1.12.6 ESR PERSONAL CAREER DEVELOPMENT PLAN TUTORING, ADVISING, OPPORTUNITIES

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

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

  *Training and collaboration*
  At the University of Vienna he can attend graduate courses on various topics of interest, seminars, informal discussions of the members of the particle physics group and German courses. A training in teaching skills is provided by the supervision of students in exercise classes. He finds the opportunity for research collaborations inside and outside this node.

At present, he is involved in an active collaboration with J. Novotný (node 8), M. Knecht (node 8) and K. Kampf (presently at Paul Scherrer Institute, Villigen, Switzerland).

*Achievements*
Since Martin Zdráhal has arrived in Vienna he has completed a research paper with his advisor in Prague and two contributions to Conference Proceedings. During the last year, he has presented the current status of his work at the FLAVIA*net* Meeting in Durham, at the International Workshop on Effective Field Theories in Valencia and the Chiral Dynamics Workshop in Bern. He has attended the Winter School on Nuclear- and Particle Physics in Schladming. Visits in Marseille and Prague allowed him fruitful scientific discussions on his research project. Martin Zdráhal had the opportunity to improve his teaching skills by supervising students at the University of Vienna.

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

  *Career Development Plan*
  Pere Masjuan is presently finishing the work on his doctoral thesis which he had started in Barcelona under the supervision of Santi Peris (node 2). His current research activities are mainly concerned with the analytical approximations to QCD: from phenomenological Lagrangians at low energy to QCD sum rules, through mathematical approximant tools, as Minimal Hadronic Approximation and, beyond, Padé Theory. In collaboration with Oscar Catà, Rafael Escribano, Santi Peris, Juan Jose Sanz Cillero and Javier Virto, he is applying these different methods to the treatment of two-point Green functions such as the $VV - AA$ correlator and the vacuum polarization function of a heavy quark, form factors and also unitarization methods. He has also studied studied the decay $\eta' \to \eta\pi\pi$ in different chiral invariant approximations. After completion of his PhD he will extend his research activity in other directions, in particular in studies of three- and four-point Green functions, electromagnetic effects in chiral perturbation theory, resonance chiral theory, the relation of ADS/CFT and theories related with Large $N_c$, Regge theory and resonances. He would also like to extend Padé Theory to other areas where this tool has not yet been used.

  *Training and collaboration*
  At the University of Vienna he can attend graduate courses on various topics of interest, seminars, informal discussions of the members of the particle physics group and German courses. He has attended the FLAVIA*net* summer school hosted at Karlsruhe Institute of Technology in September 2009. He finds the opportunity for research collaborations inside and outside this node. At present, he is involved in an active collaboration with Rafael Escribano, H.Z. Guo, Santi Peris, Juan José Sanz Cillero (node 2), Oscar Catà and Javier Virto (node 5) and with Gerhard Ecker and Helmut Neufeld (node 10).

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

## 1.13 Node No. 11: Germany–North

### 1.13.1 OFFERED PH. COURSES (LOCALLY)

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

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

### 1.13.2 OFFERED COURSES at ANY LEVEL of interest for the FLAVIANET

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

### 1.13.3 VISIT of SENIOR SCIENTISTS from OUTSIDE the NETWORK

- Various visits of senior scientists.

### 1.13.4 ORGANIZED SCHOOLS

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

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

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

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

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

### 1.13.5 GENERAL TRAINING

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

### 1.13.6 ESR HIRED

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

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

**LONG-TERM CAREER OBJECTIVES (over 5 years)** 1. Goals: I intend to keep studying possible improvements to current simulation techniques, in particular I would like to learn about reweighting techniques currently developed at the CERN FLAVIAnet node. I will also put my effort in calculating physical quantities and improving current results and practices, also by means of the newly developed simulations techniques.

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

To gain a better understanding of current simulation techniques further studies in the literature are needed. Collaboration with others members of Flavianet could also help my understanding of the main current issues that need to be adressed in the near future of lattice simulations.

**SHORT-TERM OBJECTIVES (1-2 years)** 1. Research results/Anticipated publications:
In collaboration with Dr. Stefan Schaefer from Humboldt University we have investigated the critical slowing down of lattice simulations towards the continuum limit. In particular we have investigated the severeness of the problem in the range of lattice spacings used in contemporary simulations and proposed a method to give more reliable error estimates. This study was presented at the XXVII International Symposium on Lattice Field Theory. It is published as a proceedings contribution and a detailed publication in a journal is in preparation.

2. Research Skills and techniques:

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

3. Research management:

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

4. Communication skills:

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

5. Other professional training

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

6. Anticipated networking opportunities:

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

### 1.13.8 ESR CAREER DEVELOPMENT PLAN, TUTORING, ADVISING, OPPORTUNITIES

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

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

**LONG-TERM CAREER OBJECTIVES (over 5 years)** 1. Goals: I intend to maintain my interest in the development of simulation techniques and to contribute to progress in that area, but to focus on the extraction of quantities relevant to flavour physics from lattice QCD.
2. What further research activity or other training is needed to attain these goals? To achieve these goals, it will be important to gain a deeper understanding of the variety of approaches taken to studying heavy quarks on the lattice, and in particular the non-perturbative matching of HQET using the Schroedinger functional.

**SHORT-TERM OBJECTIVES (1-2 years)** 1. Research results/Anticipated publications: I have now invested a lot of effort in learning about the current simulation algorithms, and have gained substantial experience both in the ordinary running of the simulations as well as in diagnosing and investigating associated problems. A couple of minor technical issues remain to be solved but, in addition to the continued management of the current simulations I expect to be involved in publications relating to the progress of the simulation programme (in particular, in relation to a number of high statistics runs that I have been responsible for, and which are intended for studies of the mixing properties of the Markov chain algorithm).
I have also written a new parallel program for the measurement of HQET 2-point correlation functions, including 1/M corrections, using all-to-all propagators. As well as using this program to efficiently perform the standard measurements for the HQET programme, I intend to conduct a study of variance reduction methods for these quantities and also to extend it for calculations of the $B^*B\pi$ coupling, which is a crucial non-perturbative input for the heavy meson chiral Lagrangian, and also for the calculation of B meson semileptonic form factors, which are essential for the extraction of CKM matrix elements from experimental data.
2. Research Skills and techniques: In order to make progress with my simulation-related research, I have had to deepen and broaden my knowledge and understanding of high-performance computing. For example, I have attended courses at the Juelich Supercomputing Centre on the specific systems which I use there, as well as courses on tuning and performance organised by the North-German Supercomputing Alliance. I have acquired experience with a broad range of debugging and profiling tools. This experience has been relevant to the development of my HQET measurement programs. For those I also had to deepen my understanding of C and learn data parallel programming with MPI. All of this will be essential to efficiently achieving the objectives described above.
3. Research management: I have assisted in organizing the SFB Meeting of March 2009 held in DESY-Zeuthen. I have also been involved in the preparation of applications for supercomputing resources at the Juelich Supercomputing Centre and at the Zuse Institut in Berlin.

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

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

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

# 2 Outreach

Science, and in particular physics, does not raise the interest of the general public as much as it should, considering the challenging questions it addresses to Nature and its far-reaching impact on everybody's life and environment. To raise the public awareness of particle physics and help increase the attractiveness of science among students, members of the FLAVIA*net* have put forward a series of activities. For each kind of activity, we will only highlight some of the contributions done inside the network, bearing in mind that all the nodes are involved at one level or another in outreach activities and that we cannot list all their contributions.

## 2.1 Outreach activities at the level of the network

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

At the beginning of July the Swiss team (node 9) held the conference Chiral Dynamics at the University of Bern, and had about 160 participants, gathering many participants of the network. The opening lecture was given by Nobel laureate Steven Weinberg who is recognized as one of the founding fathers of the field which plays a prominent role in the Flavianet activities. Steven Weinberg also gave a public lecture on "Cosmic dark matter". The lecture has been widely publicized in the city of Bern and was also one of the activities celebrating the 175. years of the University of Bern. About 600 people came to the lecture (about half of them in the lecture hall where Weinberg was speaking and the other half in a second lecture hall where we had set up a live video transmission).

## 2.2 Science week and open days

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

- In 2009 Science Week (19-26 September 2009), the Frascati laboratories was open to the general public members of FLAVIA*net* belonging to the KLOE experiment, have guided visitors through the laboratories to explain the goals and methods of research in particle physics.

- Laboratories on the Orsay and Marseille campus (node 8) take part regularly in the French Science Week (Fête de la Science), in particular its edition in October 2008. Members of the network belonging to LAL and LPT laboratories gave outreach conferences to secondary school pupils, using as a support the journal "Élémentaire" described below.

- On March 14. 2009, the University of Bern presented itself to the public during the so-called "Fakultätstag" (day of the faculties). Particle physics (theoretical as well as experimental) was involved heavily. Members of node 9 had two tables showing experiments and computer calculations and large posters illustrating our activities. In addition four short lectures were given on particle physics

The Nobel Prize in Physics 2008 was deeply related to the different areas covered by the network, which gave the opportunity for researches of FLAVIA*net* to promote their field of research for high schools, museums or cultural centres: J. Soto (Simetries subtilment trencades) [node 2] U. Nierste(Vom Weltall zur Weltformel: Rätsel der modernen Physik) [node 4], J. Bijnens (On the connection between magnets, the Higgsparticle and a V.I.P. party, and The Nobel Prize in Physics 2008: Broken Symmetries) and J. Eeg (Symmetrier som brytes - Nobelprisen 2008) [node 7], S. Descotes-Genon (A la poursuite de l'antimatiere) [node 8].
Other topics were also covered in talks for general audiences, in connection with LHC Physics: A. Pich (The Large Hadron Collider: a trip inside matter) [node 1], Q. Matias (L'Energia Fosca de l'Univers: L'ultima frontera) and R. Escribano (The LHC: the last frontier of particle physics) [node 2], P.J. Edwards (LHC talks) [node 3], L. Lellouch (L'infiniment petit révélé par les superordinateurs) [node 8], Helmut Neufeld (What is Particle Physics ?) [node 10].
In addition, we mention the IPPP Institute in Durham (node 3), which is very active in promoting family shows to explain the goals of the LHC to a broad audience. 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 (node 1) has also organized a big photographic exhibition about the LHC, which is now touring over a dozen of Spanish towns. It is an open exhibition which takes 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 are organized in parallel.

# 3 Conclusions

The FLAVIA*net* network is offering 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 constitutes a very lively, cutting-edge scientific framework offering countless concrete and well structured opportunities to interact with the best European and International experts in this research field. This network 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.