EUROPEAN FLAVOUR PHYSICS 2006–2010

Final report on the research activity of the
Research and Training Network FLAVIA*net*,
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between Oct 1, 2006, and Sep 30, 2010.

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Contents

This report summarises our research activity during the entire FLAVIA*net* funding period. We summarise the research achievements of the 11 nodes in Sect. 1. In Sect. 2 we list the publications of our network. Sect. 3 describes the presentation of our scientific results at international conferences and describes our networking activity. Sect. 4 is devoted to the economic spin-off of the network's research. Finally we summarise.

1 Research Achievements

The research of the 11 FLAVIA*net* nodes listed in Tab. 1 is organised in 6 working groups:

No.	Node	Acronym	Institutions involved	Sc. in Charge
1	Spain-V	UVEG	UVEG, CSIC, U. Murcia, U. Groningen (Holland)	A. Pich
2	Spain-B	UAB	UAB, UB, UPC (Barcelona), U. Granada, U. Huelva	S. Peris
3	UK	UDUR	U. Durham, U. Oxford, U. Southhampton	M. Pennington
4	Germany-S	UniKarl KIT-U	TTP, EKP (Karlsruhe), RWTH (Aachen), TU, MPI (Munich), U Siegen	U. Nierste
5	Italy	INFN	Frascati, Bari, Bologna, Milano, Napoli, Pisa, Roma (1,2,3)	G. Isidori
6	Poland	Univ. of Silesia	U. Silesia, INP (Cracow), INS, ITP-WU (Warsaw)	H. Czyż
7	Nordic	ULUND	U. Lund (Sweden), Helsinki IP (Finland), U. Oslo (Norway)	J. Bijnens
8	France	CNRS	LPT, IPN, LAL (Orsay), CPHT-X, LLR-X (Palaiseau), LPT (Strasbourg) CPT, CPPM (Marseille),LPTA (Montpellier), Ch. U. Prague (Czech R.)	S. Descotes-G.
9	Switzerland	UBERN	U. Bern, U. Lausanne, U. Zürich, CERN	G. Colangelo
10	Austria	UNIWIEN	U. Wien, U. Bratislava (Slovakia), U. Ljubljana, Inst. J. Stefan, U. Maribor (Slovenia)	H. Neufeld
11	Germany-N	DESY	DESY (Zeuthen, Hamburg), Humboldt U. Berlin, U. Bonn, U. Mainz, U. Münster	R. Sommer

Table 1: Nodes as laid out in Annex I of the FLAVIA*net* contract. Node 4 has been relabeled into Node 12 after University of Karlsruhe changed into Karlsruhe Institute of Technology.

No.	field	convenors
1	Kaon physics	J. Bijnens, G. Isidori
2	B-physics	P. Ball, F. De Fazio, U. Nierste
3	Tau-charm and quarkonium physics	N. Brambilla, M. Jamin
4	Analytic approaches to non-perturbative QCD	M. Knecht, E. Pallante
5	Lattice methods	G. Colangelo, R. Sommer
6	Radiative return and Monte Carlo tools	H. Czyż, J. Kühn

FLAVIA*net* funds were used to employ the following ESR and ER:

Name	institution	
Simone Bifani	U Bern	ESR
Michael Donnellan	DESY Zeuthen	ESR
Clark Downum	U Barcelona	ESR
Miguel Escobedo	U Milan	ESR

Cailin Farrell	U Barcelona	ESR
Patrick Fritzsch	U Southampton	ESR
Ruben Garcia-Martin	CNRS, IPN Orsay	ESR
Floriana Giannuzzi	IPPP Durham	ESR
David Greynat	IFIC, Valencia	ER
Zhi-Hui Guo	UA Barcelona	ESR
Artyom Hovhannisyan	U Karlsruhe/KIT	ER
Sergiy Ivashyn	U Silesia	ESR
Ilaria Jemos	U Lund	ESR
Renata Jora	INFN Rome	ESR
Jernej Kamenik	INFN Frascati	ER
Konstantin Kanishev	U Warsaw	ESR
Pere Masjuan	U Vienna	ESR
Vicent Mateu	MPI Munich	ESR
Emiliano Molinaro	IPPP Durham	ESR
Stefano Nicotri	U Durham	ESR
Nils Offen	CNRS, LPT Orsay	ESR
Emilie Passemar	U Bern	ESR
	IFIC, Valencia	ER
David Palao	INFN Rome	ESR
Alberto Ramos	CNRS Marseille	ER
Jacobo Ruiz de Elvira	IPPP Durham	ESR
Pablo Roig	INFN Frascati	ESR
	CNRS, LPT Orsay	ESR
Maximilian Stahlhofen	UA Barcelona	ESR
Francesco Virotta	DESY Zeuthen	ESR
Javier Virto	INFN Rome	ESR
Martin Zdrahal	U Vienna	ESR

In the following we describe the scientific activity of the nodes with emphasis on the relation to our milestones listed in Tab. 3.

1.1 Activity of the nodes

Node No. 1: Spain-V (Universitat de València Estudi General [UVEG])
First Year: Our research has covered milestones 1–3, 6–17 and 19. Different aspects of meson and baryon interactions at low energies have been studied (milestone no. 1) [1–6]. In a joint work with the Vienna and Bern nodes the two-flavour $O(p^6)$ mesonic chiral Lagrangian has been revisited [7] and first results on the strange quark mass contributions to $SU(2)$ LECs at the two-loop level were presented [8]. A new method to determine the LECs of ChPT at NLO in $1/N_C$ has been presented and L_8 and C_{38} have been estimated [9] (milestone no. 2). Together with the Germany-South node, progress has been achieved in the comprehension of the resonance saturation of $SU(3)$ LECs at the one-loop level [10, 11]. In collaboration with the Switzerland and

Tasks		Working groups					
Strong sector of the Standard Model		1	2	3	4	5	6
1	Low-energy meson-meson interaction	•			•		
2	Strong chiral low-energy couplings	•			•	•	
3	QCD parameters: m_q, α_s	•	•	•		•	
4	Hadron spectroscopy		•	•	•	•	•
5	Light-cone distribution amplitudes		•		•	•	
6	Hadronic Vacuum polarisation and $(g-2)_\mu$			•	•		•
Electroweak sector of the Standard Model		1	2	3	4	5	6
7	$\|V_{us}\|$ ($K_{\ell 2}$, $K_{\ell 3}$, τ)	•		•		•	•
8	Weak chiral low-energy couplings	•		•	•	•	
9	Weak kaon matrix elements, ϵ'/ϵ and $\Delta I = 1/2$	•			•	•	
10	Non-leptonic B and D decays		•	•	•	•	•
11	D and B semi-leptonic form factors		•	•	•		•
12	Radiative corrections in Monte Carlo generators	•	•	•			•
13	Global assessment of CKM mechanism	•	•	•			
Physics beyond the Standard Model		1	2	3	4	5	6
14	Rare K and B decays	•	•		•	•	
15	$b \to s$ transitions		•		•	•	•
16	τ-charm tests of the Standard Model			•	•	•	•
17	Supersymmetric GUTs		•			•	
18	Signals of alternatives to supersymmetry	•	•		•	•	
19	Global CKM fits for New Physics models	•	•	•			

Table 3: Milestone tasks according to the FLAVIA*net* contract.

Germany-North nodes, we are pursuing a lattice determination of the LECs of ChPT, including also the weak interactions, using Ginsparg-Wilson regularizations and finite-size scaling techniques in the ϵ-regime. We are currently studying meson current correlators at different volumes and lattice spacings [12]. A computation of the chiral condensate through a finite-size scaling study on the lattice is also in progress [13]. Lattice calculations of light-quark masses and decay constants with twisted-mass fermions have been performed in collaboration with DESY and INFN [14, 15] (milestone no. 3). Our lattice activity also includes a fully-dynamical study of hyperon-nucleon scattering [16] and the analysis of quenched-penguin and charm effects on the $\Delta I = \frac{1}{2}$ rule and ε'/ε [17–19] (milestone no. 9).

In collaboration with Marseille, a multi-scale analytical technique is being applied to the calculation of the muon magnetic anomaly $g-2$ (milestone 6) and the $K_{\ell 3}$ form factor $f_+(0)$ at the 2-loop level (milestone no. 7). Radiative corrections [20, 21] to $\pi/K \to e\bar{\nu}_e[\gamma]$ have been studied at $\mathcal{O}(e^2p^4)$. The interplay between form-factors and QCD constraints in the case of the radiative pion decay has also been explored [22]. The most recent Babar and Belle data have been used to improve the V_{us} determination [23–25] and update other Standard Model tests from

τ decay [26–28] (milestones no. 7,16).
The physics potential of a future Super-B factory (milestones no. 10,11,14–16) has been analyzed in collaboration with other FLAVIA*net* nodes [29]. Some supersymmetric flavour scenarios have been studied, together with the INFN node [30] (milestones no. 17) and constraints on new-physics sources of CP violation have been obtained [31, 32] (milestones no. 13,19). The last developments of the Monte Carlo event generator PHOKHARA (milestone no. 12) have been presented in [33]. Different corrections to high-energy processes within and beyond the Standard Model have been also studied [34–38]. Some members of the Valencia node are currently working within the Babar collaboration at the SLAC B Factory.
Second Year: In collaboration with nodes 9 and 11 [59] a detailed comparison between the results of (quenched) lattice QCD and the predictions of (quenched) ChPT at NLO has been performed. In particular, two different chiral regimes (p- and ϵ-regimes) have been considered. Volume and quark mass dependence of current correlators has been studied. In the ϵ regime, also the dependence on the topological charge has been investigated. Finally, the leading order LECs F and Σ have been extracted in the two regimes (milestone no. 2): the agreement among those independent determinations shows that quenched QCD is well reproduced by quenched chiral effective theory at leading order.
The determination of LECs of ChPT is a relevant task for its predictability in low-energy hadron physics. Together with a calculation of the vector and axial-vector two-point functions at NLO in the $1/N_C$ expansion, a subleading estimation of L_{10} and C_{87} has been presented [60] (milestone no. 2). In addition and in collaboration with Bern (node 9) we have worked out the strange quark mass contributions of the electromagnetic $SU(2)$ LECs at NLO [61]. Similar results for the strong $SU(2)$ LECs at NNLO are in preparation.
We have obtained interesting results in the reaction $\gamma\gamma \to \pi\pi$ [62,63], extending the applicability of dispersion relations. We also studied the implication of strong scalar meson-meson dynamics on the pseudoscalar self-energies arriving to two constraints involving the chiral counterterms L_4, L_5, L_6 and L_8 [64]. In ref. [65] we studied the $I = 0$ and 1/2 S-wave meson-meson dynamics up 2 GeV, including multi-particle states (milestone no. 1). We have identified the lightest scalar glueball corresponding to the $f_0(1710)$ and a strong contribution to the $f_0(1500)$. The first scalar octet at around 1.4 GeV was identified as mainly an octet (milestone no. 4).
In collaboration with the node 4 [37,66] we have studied the production of exotic resonances and its decay to top-antitop quark pairs at Tevatron and the LHC. In addition a new method for the computation of cross-sections of multipartonic processes at the LHC with NLO accuracy have been developed in [67, 68]. Finally the phenomenological predictions of Grand Unified Models (GUT) and its conections with proton decay have been presented in [69] (milestones no. 17, 18).
In collaboration with Marseille (node 8) we developed a new general multi-scaled technique based on multidimensional inverse Mellin transformation [70] to obtain asymptotic expansions. We illustrated this by an application on the $g-2$ of the muon at 4 and 5 loops level (milestone no. 6). In collaboration with Bern/Zürich (node 9) we are applying this technique to the calculation of chiral integrals involved in the calculation of Kaon form factors (milestone no. 7). Also in collaboration with Orsay (node 8) we are looking for new applications of the Mellin-Barnes representation of QCD.
The group of Groningen addresses three lines of research. The first one is devoted to Lattice

field theory for baryon interactions (milestone no. 4) and is part of the effort of the European Twisted Mass Collaboration (ETMC), which involves members of nodes 1, 8 and 11. The second line is a thorough investigation of how additional flavours of matter modify the phase structure of non-abelian gauge theories, in particular the transition from a confined to a deconfined phase [71]. Finally the third line aims to isolate a mechanism for the generation of the flavour and neutrino mass hierarchies within scenarios with extra dimensions (milestone no. 18). A more mathematical investigation of how Majorana spinors in four dimensions can be generated through boundary conditions on the compactified extra dimension(s) is in publication [72].
Tau physics is an important tool both to analyse the hadronization of QCD currents (in the semileptonic decays of the tau lepton) and to explore new physics (like in lepton flavour violation tau decays). Along these lines we have studied the latest data by the Belle experiment in the $\tau \to \nu_\tau K_S \pi$ decays [73], in colaboration with node 2, and lepton flavour violation tau decays in a constrained MSSM-seesaw scenario [74].
The research activities of the Valencia group in the BaBar experiment have expanded on the measurement of the CKM angle gamma [75–77], Mixing and CP Violation in D decays [78, 79], the measurement of $|V_{ub}|$ using semileptonic decays [80], and the study of hadronic form factors in semileptonic D meson decays [81].
Third Year: The participants node 1 (Valencia, Spain) have worked in the following specific lines of research along the last year :

- We have determined numerical values for some low-energy coupling constants in the chiral lagrangian from inclusive tau data [82–84].
- We have reanalysed the π-π phase shifts from $K \to \pi\pi$ decays [85].
- We have performed an analysis of the structure of the Yukawa couplings in the Two-Higgs-Doublet model [86].
- We have extended the mechanism of resonance saturation in Chiral Perturbation Theory at next-to-leading order in the expansion $1/N_C$ [87, 88].
- We have studied the bounds on couplings of the effective field theory beyond the Standard Model in the semileptonic decays of light quarks [89].
- The hadronization procedure of the vector and axial-vector currents in the semileptonic decays of the tau lepton has been thoroughly studied.
- We have worked out explicit constructions of seesaw models with a low scale and minimal flavour violation [90].
- We have performed the first study of finite-size scaling of heavy light mesons.
- We have explored the effects of a flavour symmetry explaining the observed Yukawa couplings on the flavour structures of the soft breaking terms in the MSSM.
- In the MSSM we can have long-lived staus if the mass difference between stau and neutralino is smaller than the tau mass. This offers a nice opportunity to measure lepton flavour violation in the decay of the stau [91].

- We have analysed the sensitivity to the Higgs sector of SUSY-Seesaw Models in the lepton flavour violating $\tau \to \mu f_0(980)$ decay [92].

Fourth Year:
The participants node 1 (Valencia, Spain) have worked in the following specific lines of research along the last year :

- We have extracted some ChPT low-energy constants and QCD vacuum condensates from the inclusive hadronic tau decay data, making use of QCD sum rules and taking into account the theoretical uncertainties associated with duality-violation effects [133–135].

- A study of semileptonic decays of light quarks beyon the Standard Model and with the use of an effetive action has been carried out [89].

- We have performed a thorough analysis of the phenomenology involved in the Aligned Two-Higgs-Doublet model [86, 136–138].

- We have studied the production of exotic resonances and its decay to top-antitop quark pairs at Tevatron and the LHC [139, 140]. These results are now being used by Fermilab to apply for an extension of the running of the Tevatron collider.

- We have continued developing our duality relation between loop and tree level Feynman diagrams and scattering amplitudes in quantum field theory and have extended those results to higher orders [141].

- We have contributed to the review on precision hadronic cross section measurements at low energies [142].

- We have analyzed the simplest scenario for gauge mediated supersymmetry breaking where the messenger are also the fields that generate neutrino masses [143].

- Within the Kaon working group, we have reviewed the determination of the CKM matrix element $|V_{us}|$ and the stringent tests of the Standard Model which can be performed with kaon decays [144]. In particular [145], we have given a critical overview of the different parametrizations available to extract the $K\pi$ form factor parameters which enter the determination of $|V_{us}|$.

- We have discussed the Callan-Treiman theorem and its interest in the test of the Standard Model. In Ref. [146] we have used the dispersive parametrization we proposed sometimes ago to reanalyse the $K_{\ell 3}$ data from the KTeV experiment in order to extract the Kπ scalar and vector form factors with a better precision.

- We have performed [147] a chiral extrapolation of the lattice data on the scalar $K\pi$ form factor $f_0(t)$ and the ratio of the kaon and pion decay constants F_K/F_π within chiral perturbation theory to two loops.

- We are studying the $\eta \to 3\pi$ decay amplitude using dispersive methods. This will allow us to extract a fundamental Standard Model parameter, namely the quark mass ratio $Q^{-2} = (m_d^2 - m_u^2)/(m_s^2 - ((m_u + m_d)/2)^2)$ which enters predominantly this decay.

- We have performed a thorough study of holographic models of QCD that can be applied, for instance, in the study of the anomalous magnetic moment of the muon [148, 149].

- An analysis of the hadronic decays of the tau lepton has been performed. In particular we have studied decays into three pseudoscalars : $\tau \to \pi\pi\pi\nu_\tau$ [150] and $\tau \to KK\pi\nu_\tau$ [151].

- A study of the $N_F = 2$ effective actions of QCD in the lattice has been performed [152, 153].

- The study of the role of the charm quark in light flavour observables has been carried out within Lattice QCD and determinations of light pseudoscalar masses, decay constants and ChPT low-energy constants with Wilson twisted mass fermions have been obtained [154]. An unquenched determination of the kaon B_K parameter from $N_f = 2$ twisted mass lattice QCD has been also obtained [155].

- An A4 flavor model for quarks and leptons in warped geometry has been developed [156].

- We have edited the proceedings of the "International Workshop on Effective Field Theories: From the Pion to the Upsilon (EFT09) (http://ific.uv.es/eft09), that was held in Valencia from 2-6 February 2009 [157].

Node No. 2: Spain-B (Universitat Autònoma de Barcelona [UAB])
First Year: The research node 2 has been involved in most of the FLAVIA*net* tasks. For example, studies on V_{us} and QCD parameters were conducted in [23–25](milestone no. 7 and 3), B semileptonic decays were studied in [174, 175] (milestone no. 11) and the problem of matching Regge behavior to perturbation theory was considered in [176] (milestone no. 3). In [177] a connection between resonance saturation and Pade theory was pointed out (milestone no. 2). Several articles which studied aspects of non-leptonic B decays within the Standard Model and in Supersymmetry are [178–180] (milestones no. 10, 14 and 15). How to use Υ(1S) decays to extract α_s was analyzed in [181], while [182] was devoted to the nucleon-nucleon potential (milestone no. 4). Some aspects of baryon physics were studied in [183, 184] (milestone no. 4,13) and, in connection with the lattice, in [16]. The usefulness of the decay $K^+ \to 3\pi$ for ϵ'/ϵ was pointed out in [185] (milestones no. 8,9 and 13), and for low-energy $\pi - \pi$ scattering in [186] (milestones no. 1,2). The gluon content in η and η' mesons was considered in [187](milestone no. 4). Finally, the collaboration of the experimental group at Univ. of Barcelona with the Babar experiment produced numerous studies of different aspects of B, D and K meson physics [188–193] (milestones no. 4,6, 10,13 and 14). More details may be found in the list of publications.
Second Year: We calculate the $\sigma \to \gamma\gamma$ width $= (1.2 \pm 0.4)$ keV using only available precise experimental data on the proton electromagnetic polarizabilities together with analyticity and unitarity [199]. In [200] we review the recent calculations and present status of the hadronic

light-by-light contribution to the muon $g-2$. We computed the spin-independent structure functions of the forward virtual-photon Compton tensor of the proton at one loop using heavy baryon chiral perturbation theory and dispersion relations. We then computed the leading chiral term of the polarizability correction to the Lamb shift of the hydrogen and muonic hydrogen [201]. We studied the constraints that the operator product expansion imposes on large N_c inspired QCD models for current-current correlators. We explicitly showed that, assumed a given mass spectrum: linear Regge behavior in n (the principal quantum number) plus corrections in $1/n$, one can obtain the logarithmic (and constant) behavior in n of the decay constants within a systematic expansion in $1/n$ [202]. We identify for the first time ever a violation of the OPE in a quantum field theory, in the 't Hooft model [203]. We have computed the ground-state energies of systems containing up to twelve pions in dynamical, mixed-action lattice QCD, and found that the chemical potential receives a substantial contribution from the $3\pi^+$ interaction at the lighter pion masses we have investigated [204]. We calculated the K^+K^+ scattering length in fully-dynamical lattice QCD with domain-wall valence quarks on the MILC asqtad-improved gauge configurations with rooted staggered sea quarks, and use three-flavor mixed-action chiral perturbation theory at NLO to extrapolate to the physical m_K^+/f_K^+ value, finding $m_K^+ a_K^+ K^+ = -0.352 \pm 0.016$ [205]. We calculated the $I = 2\pi\pi$ scattering length in fully-dynamical lattice QCD with domain-wall valence quarks on the asqtad-improved coarse MILC configurations, and use two- and three-flavor mixed-action chiral perturbation theory at NLO to perform the chiral and continuum extrapolations, finding $m_\pi a_{\pi\pi}(I = 2) = -0.04330 \pm 0.00042$ [206]. We obtained a model independent expression for $B_0(m_u+m_d)$ from the electromagnetic correction to the η to 3 neutral pions [207]. All three-point order-parameter Green functions are computed at the next-to-leading logarithmic level. This calculation is a necessary ingredient for the matching of those Green functions with the resonance chiral theory at the corresponding level [56]. Recent experimental data on the decay $\tau^- \to \nu_\tau K_S \pi^-$ from the Belle collaboration are fit with a description of the required form factors based on analyticity, unitarity and the resonance chiral theory. The fits allowed to extract the resonance parameters of the $K^*(892)$ meson as well as the low-energy slopes of the $K\pi$ vector form factor [73]. The determination of α_s from hadronic τ decays is revisited. Based on a renormalon model of higher-order perturbative corrections to the Adler function it is demonstrated that α_s extracted from τ decays turns out significantly lower than found in previous determinations [208]. Final state polarization in $B \to VV$ decays are studied comparing $b \to s$ decays with their U-spin counterparts [209]. Three different strategies to extract the weak mixing phase of the B_s system together with comments on the isospin, forward-backward and polarization fraction of the K^* in the decay $B \to K^* l^+ l^-$ are discussed [210]. New observables sensitive to the longitudinal spin amplitude of the K^* in the decay $B \to K^* l^+ l^-$ are constructed and calculated in the framework of QCDF. They are analyzed in the SM and supersymmetry including their experimental sensitivity at LHCb and Super-LHCb [211]. We performed a phenomenological analysis of radiative $V \to P\gamma$ and $P \to V\gamma$ decays in order to determine the gluonic content of the η' wave function [212]. We deduced the η-η' mixing angle is from an updated phenomenological analysis of J/ψ decays into a vector and a pseudoscalar meson [213]. We calculated the radiative decays $V \to S\gamma$ and $S \to V\gamma$ with $V = \rho, \omega, \phi$ and $S = a_0, \sigma, f_0$ within the framework of the Linear Sigma Model [212]. We propose a low energy effective field theory of QCD at the scale of pion mass for the $N_B = 2$ sector, N_B being the baryon number,

which contains two dibaryon fields in addition to the nucleons and pions. We calculate the scattering amplitudes at next-to-leading order for the ${}^1S_0$ and ${}^3S_1$ channels in this framework and obtain an excellent description of the phase shifts for center of mass energies in the $0 - 50MeV$ range [214]. We illustrate how to apply modern effective field theory techniques and dimensional regularization to factorize the various scales which appear in non-relativistic bound states at finite temperature. We discuss in detail the interplay of the hard, soft and ultrasoft scales of the non-relativistic system at zero temperature with the additional scales induced at finite temperature. We also comment on the implications of our results for heavy quarkonium bound states in the quark gluon plasma [215]. We study the photon induced Lambda(1520) production in the effective Lagrangian method near threshold [216]. With the help of a model, we study the potential impact of duality violations on the determination of OPE parameters and, in particular, on the determination of α_s. We devise a method to extract these parameters from the experimental data in the presence of duality violations [217]. Using rational approximants, we determine the value of one of the order-p^6 parameters of the chiral Lagrangian. The new method used allows a better control of the systematic error than in previous determinations [218].

Third Year: Hadronic τ decays are a providential system to investigate low-energy QCD and to determine fundamental QCD parameters like the strong coupling α_s, quark masses and QCD condensates. The essential experimental inputs in such an analysis are spectral decay distributions for basic mesonic correlation functions which have in the past dominantly been obtained by the Aleph collaboration and might be remeasured in the future by the B-factory experiments BaBar and Belle. A study of the $K\pi$ vector form factor has been undertaken [219] as well as the scalar form factor [220] (milestones 1, 2 and 16). Furthermore, we have studied the impact of duality violations (i.e. failure of the Operator Product Expansion to reproduce the spectral function) on the current determinations of α_s from tau decay (milestone 3 and 16) [221–223]. Concerning duality violations and properties of the Operator Product Expansion, a theoretical study of deep inelastic scattering in the 2-dimensional 't Hooft model has been carried out, with the result that maximal violations of quark-hadron duality have been found, as it is expected for a large N_c analysis. For the moments, violations of the operator product expansion at next-to-leading order in the $1/Q^2$ expansion have been explicitly calculated and identified [224]. We have also used the mathematical theory of Pade Approximants to complement perturbative calculations of a heavy quark threshold, obtaining the value of a constant at $\mathcal{O}(\alpha_s^2)$ (milestone 3) which has not been possible to calculate by means of state-of-the-art ordinary Feynman diagram techniques [225]. We have also computed the ghost-gluon vertex on the lattice and the size of the gauge-dependent dimension-two gluon condensate [226] (milestone 3). Charmed baryon resonances were also analyzed through mechanisms which can generate them dynamically from the s-wave interaction of mesons and baryons in a coupled channel scheme [227]. Moreover, the static heavy quark energy has been evaluated at the highest order ever in perturbation theory [228]. Also, we have calculated at NNLO the nucleon nucleon scattering at low energies in a recently proposed chiral effective theory with dibaryon fields [229] and we have shown the constraints that the effective string theory of QCD puts on lattice data for the subleading potentials [230]. Work has been carried out on the extraction of the η-η' mixing angle and the gluonium content of the η' meson from an updated phenomenological analysis of $V \to P\gamma$ and $J/\psi \to VP$ decays [231]. All the previous processes are of interest for ongoing experimental programs at Frascati, Jülich and

Novosibirsk. Concerning Chiral Perturbation Theory, we have determined the $O(p^6)$ low energy constants appearing in π-π scattering [232,233] (milestones 1 and 2) . For the physics of baryons on the lattice, we made an extensive high statistics analysis of hadronic correlation functions in order to determine the ground state baryon masses with fully quantified uncertainties that are at or below the 0.2-level in lattice units [234, 235] (milestone 4). A reanalysis of the error associated with the light by light contribution to muon g-2 has been made, where we have produced a critical review of the present knowledge of this quantity together an estimate that has become the standard value used [236–240] (milestone 6). Finally, we have determined L_{10} at order p^4 and C_{87} at p^6 using tau data [82–84, 241] (milestones 2 and 16).

Fourth Year: A study of resonance saturation has been carried out in [247]. The scattering of proton emission in the kaon-nuclei scattering was considered in [164]. On the lattice, chiral symmetry breaking was studied in [248] and the ghost-gluon coupling in [249]. Lepton flavor violation in the context of GUT theories were analyzed in [250]. The kaon bag parameter B_K was re-analyzed with twisted-mass lattice techniques in [155] and the physics of the KLOE-2 experiment was expounded in [128]. An evaluation of the CKM angle $|V_{us}|$ was presented in [144]. Novel spectroscopies of the Charmonium and Bottomonium systems were appraised in [251]. The kaon-pion vector form factor was studied in [252]. In ref. [253, 254], inclusive electromagnetic decays of heavy quarkonium were analyzed in QCD; and, in [255], the QCD static potential was studied for lower-than-four space-time dimensions. Radiative τ decays were considered in [256], while positivity constraints for the low-energy constants of the chiral Lagrangian were obtained in [257]. A new method for the combined resummation of threshold, low- and high-energy expansions for heavy-quark correlators was obtained in [258]. Finally, studies of muonic hydrogen bound states at finite temperature were done in [259] and, for the case of heavy quarkonium, in [260]. A determination of the $\Lambda_{\overline{MS}}$ parameter of QCD was made in [261] from a study of the QCD static energy; and an effective field theory for dibaryon fields was set up and studied in [262].

Node No. 3: UK (University of Durham [UDUR])

First Year: The UK node has contributed to the mission of Working Groups 1 [263–266], 2 [29, 174, 175, 194, 267–276], 3 [277–285], 4 [286–292] and 5 [195, 293–302] and milestones 1-5, 7-11, 13-15 and 17-19.

Lattice calculations using partially twisted boundary conditions of Ref. [295] have proved an efficient method for determining hadronic electromagnetic and weak form factors as a function of momentum transfer. Using new high precision data on $B \to \pi$ semi-leptonic decays, a model independent value for the magnitude of the CKM element V_{ub} is extracted [274], which disagrees by 2σ from the Heavy Flavour Averaging Group result using inclusive decays. Using lattice data to fix the form factor relevant to the same semi-leptonic decay, similar conclusions are reached in Ref. [174]. The ability to discover new physics signatures in heavy flavour decays depends critically on the precision with which Standard Model physics predictions can be made. In Ref. [273] the branching ratios, CP and isospin asymmetries in the radiative decay of B's to vector mesons, V, in $B_{u,d,s} \to V\gamma$ are calculated not just including QCD factorisation results, but using light-cone sum rules to go beyond this. This sets benchmarks for new physics searches.

In Ref. [289, 292] the behaviour of the $\overline{q}q$ condensate as a function of quark mass is determined in strong coupling modellings of QCD based on solutions of the Schwinger-Dyson equations and from lattice results.
One of the highlights of recent high precision studies of heavy flavour decays is the discovery of new and unexpected hadrons. This has led to the discussion in Ref. [281, 284] of how to resolve what we do not know. Dalitz plot analysis of the favoured $D^+ \to K^-\pi^+\pi^+$ decays with 53,000 events from the FOCUS experiment provide a dramatic testing ground for our understanding of hadron dynamics. The analysis presented in Ref. [283] shows these data are dominated by two body interactions consistent with all known data on the $K\pi$ final state, but at a greater level of precision.
Second Year: The UK node has contributed to the mission of Working Groups 1 [263, 303–308], 2 [303, 309–312], 3 [313–320], 4 [287, 288, 321] and 5 [263, 293, 298, 304–308, 310, 311, 322–324] and milestones 1,2,4,5, 7-11, 15 and 18.
Ref. [303] summarizes the results of working group 2, B, D, and K decays, of the workshop "Flavour in the Era of the LHC", held at CERN from November 2005 through March 2007. It provides, on one hand, a coherent, up-to-date picture of the status of flavour physics before the start of the LHC; on the other hand, it aims to initiate steps on the path towards integrating information on new physics from high-p_T and flavour data. Ball et al. contributed to the sections on weak decays of hadrons and QCD, radiative penguin decays and B-meson mixing. In Ref. [309], to be published in Physics Letters B, Ball et al. investigate the light-cone distribution amplitudes of the Λ_b baryon, which is a necessary ingredient in analyses of Λ_b decays into light hadrons. The QCD evolution equation is derived and solved to leading order in the QCD coupling. A simple model of the distribution amplitude is presented.
The Oxford group has studied exotic hadrons, focussing on methods to determine the nature of various enigmatic hadrons that may be molecules, hybrids or misidentified non-resonant effects [313–315]. Ref. [313] in particular criticises existing work in the literature and clarifies the flavour dependence of molecule formation, in both exotic and non-exotic channels. Ref. [314] shows that if the tetraquark $Z(4430)$ is a real state, then photoproduction may be used to clarify its status. Ref. [315] compares the flavour dependence of hybrid signals and effects driven by π exchange as a way of searching for, or eliminating, hybrid meson candidates. Hadron production of various flavours in charmonium decays is discussed in [316] and the potential for finding exotic light-flavoured hybrids in these decays evaluated. In Ref. [317] Close and Donnachie present a state-of-the-art treatise on electromagnetic interactions of hadrons. This will be a classic reference for a generation of experimentalists and phenomenologists.
The Southampton Group have been performing lattice computations with chiral fermions to obtain fundamental quantities in flavour physics. Perhaps the highlight has been the precise determination of the V_{us} element of the CKM matrix by calculating the semileptonic form factor of $K_{\ell 3}$ decays [305]. This work is being continued through the implementation of *partially twisted boundary conditions* to enable the determination of the form factor without the need for an extrapolation in the momentum transfer. A related project, based on the use of these boundary conditions, has been the first calculation of the pion's electromagnetic form factor at low values of the momentum transfer and the determination of the charge radius. Another important aspect of our lattice work are the implications for chiral perturbation theory [323]. In addition to the

evaluation of the low energy constants for pionic quantities we have studied the range of validity of one-loop chiral perturbation theory and find that it fails above about 400 MeV, and in particular for the strange quark. For this reason we have developed SU(2) chiral perturbation theory for the kaon sector, and this was one of the major Southampton contributions to ref. [323]. We advocate this as the method of choice for chiral extrapolations in kaon physics. Other significant Southampton contributions have included the evaluation of the decay constants of vector mesons [293, 323] and the low moments of parton distribution amplitudes [293]. In non-lattice flavour physics our work has focussed on the determination of the V_{ub} matrix element using analytical techniques.

Two photon production of hadronic resonances is one of the clearest ways of revealing their composition. A major input into the study of the enigmatic scalars is provided by data on $\gamma\gamma \to \pi^+\pi^-$ from Belle with a hundred times the statistics of all previous experiments. Pennington with the Belle group [319] have published a complete Amplitude Analysis of the world data on integrated and differential cross-sections on $\gamma\gamma \to \pi\pi$ and provided a new determination of the radiative widths of low mass isoscalar resonances [318, 320].

Third Year: The UK node has contributed to the mission of the Working Groups 1 on kaon physics [325, 325–327], 2 on B-physics [242, 325, 328–330], 3 on tau-charm and quarkonium physics [112, 325, 331–338], analytic approaches to non-perturbative QCD [325, 339–342] and lattice methods [325, 343–346].

The Durham group working with other nodes [329] have studied the rare decay $B \to K^*\mu^+\mu^-$. This mode is regarded as one of the crucial channels fro B-physics and golden channel for LHCb. The polarization of the K^* allows a precise angular reconstruction that results in observables that offer important tests of the Standard Model and its extensions. Those observables with the largest impact from New Physics are identified, see also [330]. Constraints on new physics contributions to the CP violating phase ϕ_d in B^0-$\overline{B^0}$ mixing are deduced in [328], and these are applied to $B \to \pi^+\pi^-$ decay.

An important theoretical development is the application of AdS/CFT correspondence to strongly coupled QCD. Nicotri has applied this to scalar sector to make predications for their masses, decay constants and couplings [342].

The Oxford group has studied exotic hadrons, focussing on methods to determine the nature of various enigmatic hadrons that may be molecules. In particular, in [337] the mixing of $q\overline{q}$ states with hybrid mesons through meson loops is explored, while in [335] possible explanations of the $Y(4260)$ and $Y(4360)$ states is presented by considering how π-exchange can lead to deeply bound hadronic molecules. Crucially tests of this explanation are outlined. In the book *Antimatter* [347] Close explains the fascinating subject of antimatter for the general public.

The Southampton Group have been extending their lattice computations with chiral fermions to obtain fundamental quantities in flavour physics, in collaboration with physicists from the University of Edinburgh and the USA. Much of this year has been spent on a detailed analysis of a simulation with a finer lattice spacing which is allowing the group to perform the extrapolation to the continuum limit. A number of papers are currently in preparation; the two most import ones include (i) a detailed simultaneous study of the chiral and continuum behaviour and (ii) an improvement of our world-leading result for the B_K parameter of K-$\bar{K}$ mixing by reducing the error due to lattice artefacts. These studies implement the new method for the non-perturbative

renormalization of lattice quantities which we proposed in [344], which eliminates infra-red effects present in earlier methods by imposing the renormalization conditions only on Green functions with no exceptional momenta. The improvement of our calculations of semileptonic $K \to \pi$ form factors for the precise determination of the V_{us} matrix element continues; the group is currently performing the calculations on the new datasets using the techniques developed in Southampton which do not require interpolations in the momentum transfer; a partial status report is contained in [348]. The Southampton group extended its techniques in applying SU(2) Chiral Perturbation Theory for kaon physics to semileptonic $K \to \pi$ form factors [327]. During the course of this work it was realized that the techniques can also be applied to processes with hard external pions, leading to the birth of the so-called *Hard Pion Chiral Perturbation Theory*. Other studies include the determination of low moments of parton distribution amplitudes (a status report was presented in [345] and a draft of the publication is being completed); a calculation of the $BB^*\pi$ and $DD^*\pi$ couplings using a non-perturbatively tuned relativistic heavy-quark action; the calculation of the decay constant of the B-meson and the amplitude for B-$\bar{B}$ mixing in the static theory (a late draft of the publication is currently being finalised for submission) and a major project on $K \to \pi\pi$ decays has been started. The Southampton group has also continued its research in non-lattice flavour physics. In [331] it is demonstrated that resonance effects and the potentially non-perturbative $c\bar{c}$ threshold region do not invalidate the standard picture of QCD factorization. Semileptonic $B \to \rho$ decays were studied in [242] using the Omnès representation to obtain the result $|V_{ub}| = (2.8 \pm 0.2)10^{-3}$ in tension with the values obtained from inclusive decays. C.Sachrajda is a member of the Flavianet Lattice Averaging Group.

Strong interaction phenomena mask the short distance weak interaction involved in the decay of a charmed particle. A detailed analysis of the highest statistics data on D_s decay to 3π has been published by Pennington with the BaBar collaboration [333] investigating the strong final state interactions.

Two photon production of hadronic resonances is one of the clearest ways of revealing their composition. Studies for the upgrade of the DAΦNE machine witha a two photon facility in the KLOE2 detector are under way. As part of this, Pennington [332] produced a report to be published as part of a special issue of European Physics Journal promoting precision low energy two photon production of meson channels. The key to understanding how hadrons are constructed from their constituent quark and gluons is the implementation of a programme to compute hadronic properties in the confinement regime. In the continuum the natural vehicle for such calculations is the system of Schwinger-Dyson, Bethe-Salpeter equations. Pennington reviewed recent progress in [339]. A key ingredient for such studies is the modelling of the interactions in the strong coupling regime ensuring the essential properties of gauge invariance and multiplicative renormalizability are maintained. A guide is provided by building these properties in QED, the study of which has recently been completed in [340].

Fourth Year: The UK node has contributed to the mission of the Working Groups 1 on kaon physics [349,350], 2 on B-physics [328,351–355], 3 on tau-charm and quarkonium physics [128, 251,347,356–359], 4 on analytic approaches to non-perturbative QCD [360–364] and 5 on lattice methods [365, 366].

The Durham group working with other nodes has been studying the ways in which many key processes are sensitive to new physics beyond the Standard Model, such as $B \to \pi\pi$ and $B \to$

$K\mu\mu$ [328, 354], as well as contributing to developing tools for analyses of forthcoming LHC data [352] and upcoming neutrino oscillation experiments [367].
An important theoretical development is the application of AdS/CFT correspondence to strongly coupled QCD. Giannuzzi and Nicotri have applied this to mesons to make predictions for their masses, decay constants and couplings [360–363] .
The Oxford group has continued its study of exotic hadrons, focussing on methods to determine the nature of a number of recently discovered hadrons with hidden heavy flavour that may be molecules. In [251] Close, Clark and Thomas study how many of the states recently discovered in e^+e^- colliders with the BaBar and Belle experiments might be deeply bound hadronic molecules generated by single pion exchange. Crucially tests of this explanation are outlined. In the books *Nothing: a very short introduction* [347] and *Antimatter* [356] Close explains the fascinating nature of the vacuum in modern physics and of antimatter for the general public.
The Southampton Group has continued to extend their lattice computations with chiral fermions to obtain fundamental quantities in flavour physics, in collaboration with physicists from the University of Edinburgh and the USA. The analysis of the results from the simulation with a finer lattice spacing, which is allowing the group to perform the extrapolation to the continuum limit, is complete and almost-final drafts of two important papers are currently being polished for publication: (i) a detailed simultaneous study of the chiral and continuum behaviour and (ii) an improvement of our world-leading result for the B_K parameter of K-$\bar{K}$ mixing by reducing the error due to lattice artefacts. These studies implement the new method for the non-perturbative renormalization of lattice quantities which we proposed earlier, which eliminates infra-red effects present in earlier methods by imposing the renormalization conditions only on Green functions with no exceptional momenta. This year we refined the methods further by using volume-averaged sources (to reduce the statistical errors very significantly) and twisted boundary conditions (to control the lattice artefacts which break the O(4) symmetry). The improvement of our calculations of semileptonic $K \to \pi$ form factors for the precise determination of the V_{us} matrix element continues with the completion and publication of our study using the techniques developed in Southampton which do not require interpolations in the momentum transfer and containing a detailed analysis of the uncertainty in the chiral extrapolation [349]. Much of the effort of the Southampton group has been devoted to developing our project on $K \to \pi\pi$ decays with the aim of understanding the $\Delta I = 1/2$ rule and the value of ϵ'/ϵ. To this end, together with our collaborators, we have generated large course lattices to study (almost) physical decays and the first very encouraging results were presented at the 2010 Lattice Symposium and two papers are currently in preparation. This will be the main research area of the Southampton Group for next two years or so. An important by product of these studies was the first detailed study of the spectrum and mixing of the η-η' system; the paper has recently been accepted for publication in Physical Review Letters [350]. We have completed and published the calculation of the decay constant of the B-meson and the amplitude for B-$\bar{B}$ mixing in the static theory [351]. Sachrajda is a member of the Flavianet Lattice Averaging Group whose first report is imminent.
The Durham group has expertise in strong coupling QCD in the continuum. A PhD student from Tübingen, Carina Popovici visited as part of her training. This resulted in the completion of work on the three quark confinement potential [364]. Two photon production of hadronic resonances is one of the clearest ways of revealing their composition. Pennington contributed to studies for

the upgrade of the DAΦNE machine with a two photon facility in the KLOE2 detector [128].
The expansion of Chiral Perturbation Theory in powers of $1/N_c$ allows the nature of low lying hadron resonances to be studied. States that are $\overline{q}q$ become more stable as the number of colours, N_c, increases, while other configurations, like tetraquark or molecular states, become wider and merge into the multi-meson continuum. Studying $\pi\pi$ scattering at one loop order in the chiral expansion sees the ρ resonance behaves with N_c just like a $\overline{q}q$ state, as expected, while the σ does not. In Ref. [358, 359], how this seemingly different nature of these states is consistent with semi-local duality. This duality works well at $N_c = 3$, but at a one loop unitarisation fails badly as N_c increases. However, the authors show that at higher orders the σ is seen to have a $\overline{q}q$ component up near 1.2 GeV, which is sub-dominant in $1/N_c$. Remarkably, this component has exactly the right structure to ensure semi-local duality holds as N_c increases. The possibility that the eighteen lightest scalars are all generated by a single $\overline{q}q$ nonet at large N_c. As N_c is reduced to its physical value, these couples increasingly to the multi-meson decay channels, dynamically generating a second set of nine states that sit close to the thresholds to which they strongly couple.

Node No. 4: Germany–South (Universität Karlsruhe (TH) [UniKarl])
First Year: The research of the node addressed milestones no. 3,5,10 and 13–18, which span the topics of all working groups. In [368, 369] we have determined the strong coupling constant α_s and the charm and bottom quark masses to four–loop accuracy (milestone no. 3) from e^+e^- scattering into hadrons. Future determinations of the top mass were addressed in [370]. The determination of electric and magnetic baryon form factors via baryon pair production through the radiative return was studied in [371]. The prime activity of the node were studies of various aspects of weak B decays in and beyond the Standard Model and thus took place in working group No. 2: Calculations within the Standard Model dealt with form factor determinations from light–cone sume rules [372] (milestone no. 5), inclusive semileptonic B decays [373] and various calculations of B decay amplitudes into two light hadrons. Using methods of soft–collinear factorisation we derived new results in the next–to–leading order (NLO) of QCD [374, 375] and made first steps into the next–next–to–leading order (NNLO) [376] (milestone no. 10). Systems involving two heavy quarks can be treated with non-relativistic QCD (NRQCD); new higher–order corrections were obtained in [377–379]. Analyses beyond the Standard Model either pursued generic, model–independent constraints on new parameters or focussed on either of two concrete scenarios of new physics: the Minimal Supersymmetric Standard Model (MSSM) and the Littlest Higgs Model with T parity. $b \to c$ transitions [380], $B \to K\pi, \pi\pi$ decays [381] (milestone no. 14), B–$\overline{B}$ mixing [382, 383] (milestone no. 15) and τ decays [384] (milestone no. 16) were studied in a model–independent way. We studied both the impact of the recent measurements of B_s–$\overline{B}_s$ mixing and D–$\overline{D}$ mixing and the implications of a potential tension in global unitarity triangle fits on the supersymmetric parameter space [385–387] (milestones no. 14,15 and 17). In [388] the boundary condition of a particular supersymmetric GUT model was considered (milestone no. 17). The papers [389–392] comprise detailed studies of quark and lepton flavour physics in the Littlest Higgs Model with T parity (milestone no. 18). Our node is also involved in experimental activity at e^+e^- colliders and the CDF detector of the Fermilab Tevatron: Currently an improved determination of the hadronic contribution to the anomalous

magnetic moment of the muon $(g_\mu - 2)$ and of the running fine structure constant at the Z^0 pole $\alpha_{\rm em}(M_Z^2)$ are achieved using new hadronic cross section data obtained at the e^+e^- particle factories DAΦNE (experiment KLOE) and PEP-II (experiment BaBar) via the Radiative Return method [193, 393–395]. Our CDF group measured the width difference among the two mass eigenstates of the B_s meson.

Second Year: The focus of the node has remained on the milestones no. 3,5,10 and 13-18, with the two major fields of precision physics within the Standard Model (SM) and the search for signals of physics beyond the SM. We computed electroweak corrections to the rare Kaon decay $K^+ \to \pi^+\nu\bar{\nu}$, which allows to probe short-distance physics with very small hadronic uncertainites, in [404]. In [208] we revisited the determination of α_s from hadronic τ decays, with a special emphasis on the question of higher-order perturbative corrections and different possibilities of resumming the perturbative series with the renormalisation group: fixed-order (FOPT) vs. contour-improved perturbation theory (CIPT). Refs. [405–408] have addresses the static quark potential at the three-loop level, hadronic τ decays in the fourth order of α_s and the QCD sum rule for the Kaon distribution amplitude. Within non-relativistic QCD top-quark pair production and the toponium and bottomonium wave- functions at the origin have been calculated at NNNLO in [409, 410]. A new activity was the combination of perturbative methods in continuum QCD with lattice gauge theory to determine the charm quark mass from current-current correlators and the B meson mass splitting [411, 412]. We studied radiative B decays in [413, 414], focusing on the calculation of logarithmically enhanced electromagnetic corrections to the decay rate and forward backward asymmetry of the inclusive rare decay $\bar{B} \to X_s\ell^+\ell^-$. Using soft–collinear factorization and the heavy quark mass expansion the structure of heavy quark jets was analyzed in [415] at next—to–leading order for e^+e^- annihilation to determine the top quark mass scheme dependence in top mass reconstruction. A new approach to quantify infrared renormalons based on a novel infrared renormalization group evolution equation was given in [416]. The approach allows to relate short-distance heavy quark masses extracted from meson decays, quarkonia and heavy quark jets to the $\overline{\rm MS}$ mass without large logarithmic terms. In [417] the two-loop soft corrections to the e^+e^- thrust and heavy jet mass event-shape distributions were computed. The complete NLO light-cone QCD sum rule analysis for $B \to \pi$ form factors has been re-investigated and updated in [418], and the work on semileptonic $b \to c$ has been continued [419, 420]. The structure of light cone distribution amplitudes has been investigated in a nonrelativistic model in [421].

Our research on physics beyond the SM has addressed studies in the Minimal Supersymmetric Standard Model (MSSM) (with and without grand unification), warped extra dimensions and the Littlest Higgs Model with T parity and has further included model-independent analyses. The MSSM Higgs sector was addressed in [422–424] analysing different observables in B physics. We studied the viability of Yukawa unification within general SUSY GUTs and found such unification to be challangend by the experimental data on FCNC processes [388, 425]. Detailed analyses of particle-antiparticle mixing, rare K and B decays and of lepton flavour violation within models with one warped extra dimension are in progress together with a more general analysis of the flavour structure of these models. We studied the impact of warped extradimensional scenarios on TeV scale physics, for the first time in the literature formulating the flavour structure of such a model. We performed a full analysis of flavour physics in that particular

model, in particular of $\Delta F = 1$ and $\Delta F = 2$ processes in the quark sector. A CKM-fitter-based model-independent analysis of possible new physics effects in $b \to s$ transitions has been performed in [426]. Minimal Flavour Violation and a study of the corresponding flavour symmetries has been performed in [427] for quarks and in [428] for leptons. Model-independent aspects of particle-antiparticel mixing are discussed in [429, 430].
The experimental activity of the node in the BaBar experiment has addressed initial-state radiation events [431–433], the production of $\rho^+\rho^-$ pairs [434] and the decay $\Upsilon(3S) - > \gamma\eta_b$ [435]. The group continues to analyse KLOE data [436–438].
Third Year: In the reporting period the focus of the theoretical work in the node has been on electroweak precision physics, effective field theories and physics beyond the Standard Model. New data on hadroproduction in electron-positron scattering have been used to update predictions on the charm and bottom masses [450] (milestone 3). Related multi-loop results were published in Refs. [451, 452]. An important two-loop calculation for $b \to u\ell\nu$ decays has been performed independently at two institutes in the node [453, 454]. Further two-loop calculations have addressed charmless hadronic two-body decays in QCD factorisation [455, 456], completing the next-to-next-to-leading order (NNLO) prediction for the decay rates of $B \to \pi\pi$ and $B \to \rho\rho$. Conceptual problems of QCD factorisation related to charm quarks were the topic of Refs. [331, 457]. A large activity was devoted to precision calculations in nonrelativistic QCD, addressing top-antitop production near threshold [458–461]. We have applied QCD light-cone sum rules to D meson decay constants [462] and semileptonic form factors [463–465] (milestones 5 and 11). The node has increased its activity on physics beyond the Standard Model, mostly studying the Minimal Supersymmetric Standard Model (MSSM): We analysed rare $b \to s$ decays (milestones 14 and 15) [329, 466, 467], and performed global analyses of several flavour observables in the MSSM (milestone 19) [468–474]. The MSSM with the boundary conditions of a Grand Unified Theory have been confronted with flavour data in Refs. [475, 476]. An alternative to supersymmetry are little-Higgs models studied in Refs. [477, 478]. We have further performed model-independent studies of new physics [97,98,479]. Additional theoretical studies in flavour physics were addressed in Refs. [480–488]. Continuing experimental work of the node has been devoted to B physics analyses at CDF (Fermilab), with publications on spectroscopy (milestone 4) [489,490]. Further the same experimental group has strengthened its activity in the BELLE experiment, which the group has joined in summer 2008.
Fourth Year: The scientists in the node have performed theoretical research on the strong and electroweak sectors of the Standard Model and on various models of new physics. The node is further involved in activities at the BaBar, KLOE, CDF-II and BELLE experiments.
Our research on the strong interation has addressed the development and applications of effective field theories for QCD, precise extraction of standard model parameters and effective field theories for the study of quarkonium suppression in heavy ion collisions (milestones no. 1,4) [260, 261, 505, 506]. Multi-loop calculations related to precision determinations of QCD parameters (milestone no. 3) or the rare decay $B \to X_s\gamma$ (milestone no. 15) have been performed in [507–511]. The increasing precision in the hadronic matrix element involved in the CP-violating quantity ϵ_K calls for a next-to-next-to-leading-log calculation of the corresponding Wilson coefficient. In [512] we have performed this calculation for the charm-top contribution to ϵ_K (milestones no. 9,13). Additional long distance contributions to this quantity are

the focus of [513]. Soft-collinear factorisation has been applied to non-leptonic (milestone no. 10) [514] and rare semileptonic decays [515]. Further we have analysed charm effects in B meson decays [516, 517] and studied semileptonic $B \to D^*$ decays at zero recoil [518] (milestones no. 10,11,13). Narrow resonances have been studied within the radiative return method (milestone no. 12) in [519].

A large fraction of the node's scientific activity has been devoted to physics beyond the Standard Model. Model-independent considerations comprise a new approach to characterising the parameter space of new-physics models [520] and a global fit to generic scenarios accomodating new physics in B–$\overline{B}$ mixing [521] (milestone no. 19). It is well-known that the rich flavour structure of supersymmetric models can easily remove the tensions seen in today's data on flavour-changing neutral current (FCNC) processes. A comprehensive analysis of these processes within the Minimal Supersymmetric Standard Model (MSSM) has been performed in [522] for the quark sector and in [523] for the lepton sector. We have studied K–$\overline{K}$ and D–$\overline{D}$ mixing with focus on the superparticle spectrum [524], hadronic electric dipole moments [525] and extreme values of the parameter $\tan\beta$ [522] (milestones no. 14,15,17,19). Alternative new-physics models (milestones no. 18,19) studied in our node include extensions of the Standard Model by right-handed currents [526], a second Higgs doublet [527] and a sequential fourth generation [528–530]. Further imprints of the Littlest Higgs Model with T-Parity on rare D decays (milestone no. 16) have been investigated in [531]. Important results of theses studies are distinctive features of the models on FCNC processes: For example, in the right-handed current model the CP asymmetries $S_{\psi\phi}$ in the B_s system and $S_{\psi K_S}$ in the B_d system are correlated [526], and a fourth generation permits spectacular effects in CP-violating decays and rare K and B decays (milestone no. 14) as well as lepton-flavour violating decays [528–530]. These departures differ significantly from the ones found in supersymmetric flavour models, littlest Higgs model with T-parity and Randall-Sundrum model studied by us previously. Finally, in the two-Higgs-doublet model with MFV and flavour-blind phases a large CP-asymmetry $S_{\psi\phi}$ in the B_s system implies uniquely (without additional free parameters) a significant softening of the tension between the CP-asymmetry $S_{\psi K_S}$ and the parameter ϵ_K [527].

A major experimental effort of our node was the participation in the data analysis of the BELLE experiment: The NeuroBayes neural network software is currently successfully applied to the analysis of B decay data with missing energy. A major topic of our B physics activity in the CDF-II experiment at Fermilab is still the decay mode $B_s \to J/\psi\phi$ [532], which gives access to the CP phase in B_s–$\overline{B}_s$ mixing. The KLOE group has studied the cross section of $e^+e^- \to \pi^+\pi^-$ [161] in the energy region below 0.85 GeV^2 with the radiative return method and has further measured the $\eta \to 3\pi^0$ slope parameter [162]. We have further determined the $\gamma\gamma^* \to \eta_c$ transition form factor at BaBar [533].

Node No. 5: Italy (Istituto Nazionale di Fisica Nucleare [INFN])

First Year: The highlights of the research activity of the node include: **I.** The production of extensive unquenched simulations of $N_f = 2$ twisted-mass Wilson fermions (with several values of the light quark masses) with the purpose of extracting continuum hadronic quantities extrapolated at the physical pion mass (milestones n. 8,9,11). Phenomenological applications of these

simulations relevant for Kaon, charm and B-physics have also been started. This research is carried out by members of the node within the ETM Collaboration [14, 15, 538]. **II.** Determination of the CKM matrix elements, analysis of rare B and K decays and of D–$\bar{D}$ mixing in the SM, in motivated new physics models (such as low-energy supersymmetry) and in general model-independent approaches [30, 387, 539–542] (milestones n. 14-18). **III.** Analysis of recent data collected by KLOE and other low-energy experiments on semileptonic K decays. Evaluation of combined averages for all the quantities relevant to the extraction of V_{us} and corresponding global estimate of this fundamental SM parameter [543, 544] (milestones n. 7-8). **IV.** Development of effective field theories of QCD with applications to the physics of heavy meson decays, heavy quarkonium, and quark-gluon plasma. Analysis of the newly observed mesons with open and hidden charm and investigations in heavy meson spectroscopy [181, 196, 545, 546] (milestones n. 3,4,5). **V.** Four-quark interpretation of the newly observed heavy mesons and corresponding development of a new spectroscopy [547–549] (milestone n. 4). **VI.** Improved determination of the hadronic contribution to $(g-2)_\mu$ [394] (milestone n. 6).

Second Year: The highlights of the research activity of the node include: **I.** Extraction of physical quantities from the unquenched simulations of $N_f = 2$ twisted-mass Wilson fermions within the ETM Collaboration [52, 557–560] (milestones n. 8,9,11). Several physical quantities, in the pseudo-scalar and vector-meson sector have been computed with unquenched up and down quark masses, corresponding to pion masses in a range from 250 to 550 MeV. Most importantly, the results have been obtained with statistical errors at the percent level while keeping lattice artifacts and finite volume effects well under control. Moreover, the ETM Collaboration has started exploratory simulations with four (up, down, strange and charm) unquenched flavours. **II.** Model-independent phenomenological analyses of new-physics effects in flavour physics [45, 303, 561, 562], including in particular B_s-mixing [563], $B \to D\tau\nu$ decays [564], and global analysis of $\Delta F = 1$ processes in the MFV framework [565] (milestones n. 14-18). Related studies about the physics case of a Super Flavour Factory [566]. **III.** Analysis of recent data collected by KLOE and other low-energy experiments on semileptonic K decays [567]. Evaluation of combined averages for all the quantities relevant to perform stringent tests of the SM, such as the CKM-unitarity test and tests of lepton-flavour universality [568] (milestones n. 7-8). **IV.** Development of effective field theories of QCD with applications to the physics of heavy meson decays, heavy quarkonium [569–573] and quark-gluon plasma (milestones n. 3,4,5). New determination of V_{ub} from semileptonic B decays [574]. Study of implications of the ADS/CFT correspondence for light meson dynamics [575, 576] **V.** Developments of a new effective theory to describe the light scalar-mesons [577] and interpretation of the newly observed heavy mesons in terms of four-quark states [578, 579] (milestone n. 4).

Third Year: The highlights of the research activity of the node include: **I.** Determination of D and K decay form factors from unquenched simulations of $N_f = 2$ twisted-mass Wilson fermions within the ETM Collaboration [602–605] (milestones n. 8,9,11). The Collaboration has continued the extraction of physical quantities in the pseudo-scalar and vector-meson sector, with unquenched up- and down-quark masses corresponding to pion masses in a range from 250 to 550 MeV. The results have been obtained with statistical errors at the percent level while keeping lattice artifacts and finite volume effects well under control. Exploratory simulations with four unquenched flavours have also been started. **II.** Phenomenological analyses of new-

physics effects in low-energy flavour physics observables with particular attention to leptonic B [104, 488, 606, 607] and D [608] meson decays. Analysis of the correlations between low-energy processes and high-energy observabels in well-motivated supersymmetric [609] and non-supersymmetric [610, 611] extensions of the SM (milestones n. 14-18). **III.** Analysis of recent data collected by KLOE and NA48 on K, η and decays [612–616]. (milestones n. 7-8). **IV.** Development of effective field theories of QCD with applications to the physics of heavy quarkonium [228, 617–619] and tau physics [620] (milestones n. 3,4,5). **V.** Developments of new effective theories to describe in a coherent way the old and the newly observed scalar mesons [341, 621–625] (milestone n. 4).

Fourth Year: The highlights of the research activity of the node include: **I.** Global analysis of leptonic and semileptonic kaon decay world data, in conjunction with precise lattice results on kaon form factors, finalized to extract $|V_{us}|$ and to perform several stringent tests of the Standard Model (Flavianet kaon WG, milestone n.7) [144]. Precise determination of light quark masses, light-meson spectroscopy, and K decay form factors from unquenched simulations of $N_f = 2$ twisted-mass Wilson fermions within the ETM Collaboration (milestones n. 8,9,11) [132, 132, 154, 155, 168, 170]. First results with four dynamical quarks with twisted-mass Wilson fermions [165]. **III.** Phenomenological analyses of new-physics effects in low-energy flavour physics observables in general terms [637, 638] and within specific extensions of the Standard Model. In particular, it has been analysed the correlation between CP violation in B_s and B_d mixing in models with two Higgs doublets and MFV [527, 639], as well as the effect of right-handed currents in the determination of V_{ub} and CP violation in $B_{s,d}$ mixing [526] (milestones n. 14-18). **IV.** Study of low-energy meson dynamics by means of holographic approaches to QCD [148, 149]. **V.** Development of new effective theories to describe in a coherent way the old and the newly observed hadrons with heavy quarks [640–645] (milestone n. 4). **VI.** Analysis of recent data collected by KLOE and NA48 on K and η decays, and low-energy $e^+e^- \to$ hadrons (milestones n. 7-8) [160, 162, 163, 646–648]. Investigation of the possible physics program of an energy upgrade of the DAFNE collider [128, 649].

Node No. 6: Poland (University of Silesia [Univ. of Silesia])

First Year: The activity of the Polish node concentrated mainly on the realisation of the milestones number 6,10,12,14,15 and 16. Two meetings of the working group 6 were co-organised. The meetings gathered not only physicists from FLAVIA*net*, but a wider group working actively in the field covered by working group 6. Calculation of the radiative corrections relevant for luminosity monitoring at meson factories and construction of necessary software tools was a subject of papers [656–658] (milestone no. 12). In [657] Mathematica program for automatic construction of Mellin-Barnes representations of planar Feynman integrals is given. It builds one loop tensorial and up to second rank multi-loop tensorial integrals, and multi-loop scalar integrals. In [656] some details concerning summations of simple QED residues coming from Mellin-Barnes representations are given. In [658] two loop radiative corrections to massive Bhabha scattering in QED for heavy fermions are calculated. They include calculation of box diagrams in approximation $m_e^2 \ll m_f^2 \ll s, t, u$. Various aspects of the B- decays were covered in papers [659–662] (milestones no. 10,14,15). The article [659] is devoted to presenting

and describing the first estimate of the $B \to X_s\gamma$ branching ratio that includes $O(\alpha_s^2)$ QCD corrections. The article [660] presents the calculation of 3-loop contributions from the 4-quark operators to the $b \to s\gamma$ transition in the limit of heavy charm quark ($m_c \gg m_b/2$). These results together with the BLM approximation form the basis for the interpolation in m_c and a detailed phenomenological analysis that was summarised in [659]. The article [661] contains a description and results of the evaluation of 4-loop anomalous dimensions for renormalisation of the Wilson coefficients in the effective theory that arises from the Standard Model after decoupling the heavy electroweak bosons and the top quark. This is the final anomalous dimension computation that was needed for the $O(\alpha_s^2)$ QCD corrections to $B \to X_s\gamma$. The paper [662] summarises the results of [659–661]. Papers [371, 663] are devoted to studies based on the radiative return method (milestones no. 6,12). In [371] it was shown how to extract baryon form factors using radiative return method and information about baryon decay products, while in [663] a short review of the research program based on the radiative return method was presented. In [664] the status of the TAUOLA and PHOTOS programs was presented with emphasis on multi-pion τ decays and radiative corrections to B - decays (milestones no. 10,12,16).

Second Year: The activity of the Polish node concentrated mainly on the realization of the milestones number 1, 3, 4, 6, 7, 10, 12, 14, 15, 16, 17 and 18. One meeting of the working group 6 was co-organized. The meeting gathered not only physicists from FLAVIA*net*, but a wider group working actively in the field covered by working group 6.

Calculation of the radiative corrections relevant for luminosity monitoring at meson factories and construction of necessary software tools was a subject of papers [665–670] (milestone no. 12). In [665, 666, 669] the complete virtual QED contributions to Bhabha scattering due to vacuum polarization effects in photon propagation were derived. The result was applied to hadronic corrections and to heavy lepton and top quark loop insertions. The first complete estimate of their net numerical effects for both small and large angle scattering at typical beam energies of meson factories, LEP, and the ILC was given. The determination of the infrared singularities of massive one-loop 5-point functions with Mellin-Barnes (MB) representations was discussed in [667,668]. Analytical reductions of one-loop tensor integrals with 5 and 6 legs to scalar master integrals was performed in [670]. The reductions are expressed in a compact form, and have been implemented in a Mathematica package called hexagon.m.

Associated production of the top quark pair and light Higgs boson at the future International Linear Collider was discussed in [671,672] (milestones no. 17,18). The background effects have been shown by comparing cross sections of three reactions, which represent different detection channels of $e^+e^- \to t\bar{t}H$, calculated with the complete sets of the lowest order Feynman diagrams with the corresponding signal cross sections calculated with the diagrams of associated production and decay of off mass shell top quark pair and Higgs boson only.

The current status of `carlomat`, a program for automatic computation of the lowest order cross sections of multi-particle reactions was presented in [673] (milestones no. 12,17,18). The results of comparisons with other multipurpose Monte Carlo programs were shown.

Mass range of the charged Higgs boson in the 2HDM with explicit and spontaneous CP violation was discussed in [674] (milestone no. 18). It was shown that it may help to distinguish between those types of the CP violation. Constraints on M_H^+ in the CP conserving 2HDM(II) were shown.

The physics case of the International Linear Collider was presented in [675] (milestone no. 18).

In [676] the introduction to the conference Photon 2007, devoted to the photon interaction with hadrons was presented (milestones no. 6,18). Open problems relevant for a search for a new physics were discussed, among them hadronic contribution to g-2 for muon.
Charge asymmetry in processes $\gamma\gamma \to \ell + \ell^- + \nu's$ was considered in [677] (milestone no. 18). Effects sensitive to New Physics were found.
The report [678] presents flavour related issues in the production and decays of heavy states at LHC, both from the experimental side and from the theoretical side (milestones no. 10,14,15). It contains a review of top quark physics, and a discussion of flavour aspects of several extensions of the Standard Model, such as supersymmetry, little Higgs model or models with extra dimensions. This includes discovery aspects as well as measurement of several properties of these heavy states.
The article [679] presents a study of the anomalous Wtb coupling effect on the $B \to X_s\gamma$ branching ratio (milestones no. 3,10,14,15). The considered couplings are introduced as parts of gauge-invariant dimension-six operators that are built out of the Standard Model fields only. Bounds on the corresponding Wilson coefficients are derived.
The present status of the physics program, which led to the development of the Monte Carlo event generator PHOKHARA was described in [680, 681] (milestones no. 1,4,6,7,12,16). In [681] an improved description of four-pion production in electron-positron annihilation and in tau lepton decays is presented. Predicting tau decay distributions from e^+e^- data and comparing these predictions with ALEPH and CLEO results, the validity of isospin symmetry is confirmed within the present experimental errors. Special emphasis is put on the predictions for $\omega(\to \pi^+\pi^-\pi^0)\pi$ in e^+e^- annihilation and in tau decay.
In [682] the program BOKASUN for fast and precise evaluation of the Master Integrals of the two-loop self-mass sunrise diagram for arbitrary values of the internal masses and the external four-momentum was presented (milestone no. 12).
The calculational precision of $e^+e^- \to \tau^+\tau^-$ and $e^+e^- \to \mu^+\mu^-$ production cross-sections in electron-positron annihilations at $\sqrt{s} = 10.58$ GeV was studied in [683] for the KKMC Monte Carlo simulation program (milestones no. 12,16).
A review the main ideas and constraints which shaped the program PHOTOS of today and enabled it widespread use was presented in [684] (milestones no. 7, 10, 12, 16). The importance of aspects related to reliability of program results: event record contents and implementation of channel specific matrix elements were emphasized.
Third Year: The Polish node concentrated last year on tasks 1,3,4,12,14 and 16.
Tasks 1 and 4: The measurement by the BES collaboration of $J/\psi \to \gamma p\bar{p}$ decays indicates an enhancement at the $p - \bar{p}$ threshold. In another experiment BES finds a peak in the invariant mass of pi-mesons produced in the possibly related decay $J/\psi \to \gamma\pi^+\pi^-\eta'$. Using a semi-phenomenological potential model which describes all the $N - \bar{N}$ scattering data, in [685] it was shown that the explanation of both effects may be given by a broad quasi-bound state in the spin and isospin singlet S wave. The structure of the observed peak is due to an interference of this quasi-bound state with a background amplitude and depends on the annihilation mechanism. More details and more complicated bound systems are studied in [686] and [687]. In [688] the features of the Resonance Chiral Theory (RChT) related to the description of the lightest scalar resonances, sigma, f0(980) and a0(980), are discussed. Major attention is paid to the fits of the

invariant mass distributions in the radiative decays of the phi(1020) meson. The study of the scalar sector in RChT is motivated by the success of the theory predictive power in numerous processes with other types of resonances. We conclude that RChT is sufficiently flexible to describe these decays, however the further quantitative improvement is required. The technical work-outs and related important questions are outlined.
Task 3: In [689] an analytical calculation of the two-loop QCD corrections to the electromagnetic form factor of heavy quarks. The exponentiation of the heavy-quark form factor was applied to derive new improved three-loop expansions in the high-energy limit.
Task 12: A review of the status of the Monte Carlo event generator PHOKHARA, developed for experiments using the radiative return method was presented in [690]. The four-pion production in electron-positron annihilation and in tau-lepton decays and the narrow resonances studies were described. In [691] the current version of 'carlomat', a program for automatic computation of the lowest order cross sections of multi-particle reactions, is described. The program can be used as the Monte Carlo generator of unweighted events as well. Reduction techniques in calculation of the one loop radiative correction to be used in Monte Carlo generators relevant for low energy flavour physics were developed in [692]. The resulting compact formulae allow both for a study of analytical properties and for efficient numerical programming. They are implemented in Fortran and Mathematica. In [693] PHOTOS was upgraded to allow for simulation of the final state photon(s) emission in decays $W \to l\nu$ and $\gamma^* \to \pi^+\pi^-$. Exact leading order matrix elements were implemented. The second process is of particular interest for the pion form factor measurement. Upgrades of TAUOLA and PHOTOS generators are presented in [694]. For the TAUOLA Monte Carlo generator of tau-lepton decays, automated and simultaneous use of many versions of form-factors for the calculation of optional weights for fits was discussed. New tests for PHOTOS Monte Carlo for QED bremsstrahlung in W decays were shown. Prototype version of the TAUOLA universal interface based on HepMC (the C++ event record) was mentioned. Its tests with the help of MC-TESTER were also discussed.
Task 14: The article [695] contains a description of the main theoretical issues that determine accuracy of the $B \to X_s\gamma$ decay width calculations. One of its central points is a critical discussion of the collinear logarithm resummation by Becher and Neubert in Phys. Rev. Lett. 98 (2007) 022003. That resummation was performed too far from the photon energy endpoint, which resulted in worsening the accuracy rather than improving it.
Task 16: A combined analysis of the electromagnetic pion and kaon form factors in the neighbourhood of J/psi and psi(2S) and of the strong decay amplitude of these resonances into kaons is presented in [483]. In the presence of a large relative phase between strong and electromagnetic resonance amplitudes the branching ratio, as measured in electron-positron annihilation, receives an additional contribution from the interference between resonance and continuum amplitude neglected in earlier papers. Our study is model independent and does not rely on the SU(3) symmetry assumptions used in earlier papers. We note that the large relative phase between strong and electromagnetic amplitudes observed in earlier analyses is model dependent and relies critically on the specific assumptions on SU(3) symmetry and breaking.
Fourth Year: The Polish node concentrated last year on milestones 6,10,12,14,15,16 and 18.
Tasks 6, 12 and 16:
The group participated in preparations of two major review publications, which gave relevant

contributions to studies within these tasks . One of them [128] concerns the KLOE2 physics program, which covers subjects vital for the flavour physics in the years to come. The group contribution concentrated on the subjects related to the error reduction in calculations of the hadronic contributions to $(g-2)_\mu$, both coming from direct measurements of the hadronic cross sections and $\gamma^* - \gamma^*$ physics. The second review paper [142] is a summary of the activity of the Working Group on Radiative Corrections and Monte Carlo Generators for Low Energies (http://www.lnf.infn.it/wg/sighad/). The FLAVIAnet Working Group on Radiative return and Monte Carlo tools (WG6) was a part of this working group. The Polish node coordinator was one of the conveners of both working groups. In this paper achievements of the last years of the experimental and theoretical groups working on hadronic cross section measurements at the low energy e+e- colliders in Beijing, Frascati, Ithaca, Novosibirsk, Stanford and Tsukuba and on τ decays were presented and prospects in these fields for the years to come were sketched. The status and the precision of the Monte Carlo generators used to analyse the hadronic cross section measurements obtained with energy scans and with radiative return method as well as the ones used to determine luminosities and to simulate τ decays was reviewed in detail. The radiative corrections fully or approximately implemented in the codes and the contribution of the vacuum polarisation were also discussed.
In [519, 696] it was shown that using the radiative return method it is possibile to study kaon and pion pair production at and around the narrow resonances J/ψ and $\psi(2S)$ and to explore the interference between electromagnetic and hadronic amplitudes. New charged and neutral kaon as well as pion form factors were derived, whith an improved description of the data in the region of large invariant masses of the meson pair. These form factors were combined with the hadronic couplings of charged and neutral kaons to J/ψ and $\psi(2S)$ and implemented into the Monte Carlo generator PHOKHARA.
In [697] the EKHARA Monte Carlo event generator of reactions $e^+e^- \to e^+e^-\pi^0$ and $e^+e^- \to e^+e^-\pi^+\pi^-$ was presented. The newly added channel $e^+e^- \to e^+e^-\pi^0$ is important for $\gamma^* - \gamma^*$ physics and can be used for the pion transition form factor studies at meson factories. In [698] several final-state radiation models was compared. Results obtained with Monte Carlo generator PHOKHARA, relevant for an error estimation at meson factory running at $\sqrt{s}$ = 1 GeV were presented.
In [699–701] a program of developing new methods and tools for calculations of the radiative corrections was pursued. An outline of a basis for planar integrals at two loops was given. Software packages Ambre and CSectors which use Mellin-Barnes and sector decomposition methods were further developed.
Tasks 10, 14, 15:
Various aspects of $B-$decays were studied in [511, 702, 703]. The last missing perturbative $O(\alpha_s^2)$ corrections to $BR(B \to X_s\gamma)$ were calculated and the current status of the corrections was reviewed. In addition large-m_c asymptotic behaviour of these corrections was studied.
Task 18: Higher dimensional interaction terms appearing in Lagrangians beyond the Standard Model were considered in [704] and their complete classification without any redundancy was presented. In [705, 706] evolution of the Universe after Electroweak Symmetry Breaking was considered, which leads to the present inert phase, containing a SM-like Higgs boson and scalar dark particles, among them a Dark Matter candidate. It was shown that if current state of the

Universe is described by IDM, then during the thermal evolution the Universe can pass through various intermediate phases, different from the inert one. These possible intermediate phases contain no dark matter, which appears only at the relatively late stage of cooling down of the Universe.

Node No. 7: Nordic (Lund University [ULUND])
First Year: The research of the node addressed milestones no. 1–3,6-7,10,14,15, which span the topics of working groups 1,2,4 and 5.
In [708–712] we studied various aspects of soft effects in B and D decays. This included the effects of chiral loops and nonfactorizable effects in several decays, this work took place in WG2 (milestones no. 14 and 15).
The work on the light-by-light contribution to the muon anomalous magnetic moment has been reviewed [197, 198] and the various calculations recalculated numerically and compared in a new way [197] (milestone no. 6). A lot of work has been devoted to NNLO calculations in Chiral Perturbation Theory. These calculations have been reviewed in [713] and have also been extended considerably during the reporting period. A bit of work was done for finite volume corrections at two-loop order [714, 715], (WG5 and milestone no 2). A lot of effort has been devoted to masses and decay constants in partially quenched Chiral Perturbation Theory as well as on how to evaluate here the eta mass and electromagnetic effects [716–719] This research has contributed to milestones and WG4 and WG5, milestone no. 2 and 3. An overall review of ChPT in the meson sector and how this is relevant for lattice QCD was also done [720]. In particular the quark mass dependence of $f_+(0)$ and meson masses has been elucidated here. Relevant for WG 1 and 5, milestones 2 and 7. In the same area preliminary results for isospin breaking at two-loop order for this quantity have been done [721]. Finally, in a major step for the study of quark masses and meson-meson interaction the calculation of $\eta \to 3\pi$ at NNLO was done and first numerical results obtained [722].
In the Helsinki group the analysis of coupling constants of the πN interaction has continued [723, 724] relevant for milestone no. 2. The Helsinki lattice group has concentrated on studying the B_S meson energy spectrum for S-, P-, D- and F-waves and also their first radial excitations. Particular attention has been paid to the P- and D-wave spin-orbit splitting [725]. To check the stability of the results several different sets of lattice configurations were used. In addition increasing amounts of smearing were introduced. This work contributes to milestone no. 4
Second Year: In this period we have contributed to milestones 1,2,7,8,9,10,11,13 which span the working groups 1,2,4 and 5. The publications [712, 720–723, 728] which appeared in the first period as preprints have now been published.
The new work in this period is in several main areas. First we have been involved in improving the theoretical predictions for $K_{\ell 3}$ decays and their relevance for the determination of the CKM element V_{us} by computing the isospin breaking correction to NNLO in Chiral Perturbation Theory [732] and by participating in the overall discussion in the kaon working group [568]. It was found that the total effect of isospin breaking at NNLO is small since there were two compensating effects, a larger value of $m_u - m_d$ is needed at NNLO but the NNLO in $K_{\ell 3}$ lowers the isospin breaking correction. Effects on the Callan-Treiman point at NNLO were also discussed.

The second area has been in working in effects relevant in nonleptonic weak decays. A new type of Penguin effect was studied in $K \to \pi\pi$ decays [733] This offshell chromomagnetic dipole increases the effect of Q_6 in this decay by about 5%.
The form-factors in semileptonic B_q to D_q decays have been studied as regards to the chiral corrections coming from chiral loops. These corrections were calculated for $1/m_Q$ suppressed operators and an extraction procedure from lattice QCD results suggested [585].
The last main area studied was the purely hadronic one where results at NNLO in ChPT for $\eta \to 3\pi$ were discussed [734] and the progress in the new dispersion analysis of πN scattering was presented in [735, 736]. This is part of an update of the old Karlsruhe-Helsinki analysis of the then existing πN data set.
Third Year: In this period we have contributed to milestones 2, 4, 9 and 11 which span the working groups 1, 2, 4 and 5.
In the field of Kaon nonleptonic decays we have made two contributions in this period. This showed that off-shell effects can have a effect of about 5% in these decays. In Lund [737] it was shown how even for large Kaon masses chiral predictions are still possible for the pionic logarithms. This was argued to be the case for more general hard processes but shown explicitly for the pionic logarithm in $K \to \pi\pi$ decays. This work built strongly on earlier work by the Southampton group of node 3 in the case of $K_{\ell 3}$.
In semileptonic B-decays the chiral corrections for the formfactors in B to D transitions were studied [607]. The influence of opposite parity multiplets was found to be comparable to the $SU(3)$ breaking.
For hadronic spectroscopy in lattice gauge theory the spectrum of excited B_s mesons was discussed in the PhD thesis which was successfully defended in May 2009 [738].
In standard Chiral Perturbation Theory (ChPT) the work for a new general determination of the Low-Energy-Constants (LECs) enjoyed steady progress. One major question here is to find tests of that are independent of estimates on LECs. This was found to be possible at next-to-next-to-leading order depsite the large number of LECs. Discussions can be found in [739–741] and the work was published in [742]. Preliminary results of the new fit for the NLO LECs were presented as well [740, 741]. In this context the reviews on the status of mesonic ChPT are also relevant [741, 743]
The new analysis of pion-nucleon scattering using dispersion relations and partial wave analysis has been going slowly forward in Helsinki. Preliminary results have been presented at the three conferences listed in the presented talks section by M. Sainio. This work will provide much needed background on strong LECs in the nucleon sector.
In Lund, work has been ongoing to study ChPT in a more general setting which might be relevant for future lattice studies of nonperturbative Higgs sectors and methods of generating fermion masses and mixings. We have here been studying higher order corrections in various models with different patterns of spontaneous symmetry breaking as well as studies for large number of flavours in these models. A first publication solved the massive nonlinear $O(N)$ model for large N and obtained the leading logarithms for the mass up to five loop order [744].
Fourth Year: The participants in node 7 (Lund, Sweden, Oslo, Norway, Helsinki, Finland) have contributed to working groups 1, 2 and 4 and milestones 2, 10 and 18 during this reporting period. We have worked in the following specific lines of research along the last year :

- We have continued studying hard pion Chiral Perturbation Theory where we studied $B \to \pi$ transition formfactors [745]. This extends the earlier work on $K \to \pi$ transition formfactors from node 3 and $K \to \pi\pi$ from year 2. Work is in progress on extending these results to all B decay formfactors.

- Work on a new general fit of Chiral Perturbation Theory at NNLO is progressing but no new results have been published.

- The renormalization group has been studied to high loop order for the decay constant, vacuum expectation values, form-factors and meson-meson scattering in the massive nonlinear sigma model [746].

- Dispersive methods are studied for the decay $\eta \to 3\pi$ in collaboration with node 8. This work has been presented at several conferences and a publication is forthcoming.

- Lund has started studying the extension of ChPT to the anomalous sector at NNLO for three flavours. First preliminary results have been presented at conferences but this project is still in its early stages.

- Dealing with spin-1 resonances in effective field theories in loop diagrams has uncertainties due to the additional degrees of freedom necessarily present in any Lorentz invariant description. This work, jointly with node 8, has been published in [747].

- Alternatives to the Higgs sector require in technicolour inspired scenarios theories that are nonperturbative. Here as for QCD, extrapolations to light fermion masses is needed on the lattice. We have calculated masses, vacuum expectation values and decay constants to two loop order in an effective field theory approximations for three general classes of such models with spontaneous symmetry breaking [748].

- The Oslo group has studied nonfactorizable contributions to $B \to \pi D$ decays. This is especially important for the decay $\bar{B}^0_d \to \pi^0 D^0$ where the factorized contribution is small [749].

- The heavy light chiral quark model as studied extensively in Oslo had a too small slope in the Isgur-Wise function in $B \to D$ semileptonic decays. By changing the heavy quark propagator in the model this can be improved and the effect also has implications for the nonleptonic $B \to D\overline{D}$ decays [750].

- We have had a long term visit of S. Lanz from node 9 during which we discussed $\eta \to 3\pi$ and dispersive methods very much and in addition a paper on finite volume correction was published [751]

Node No. 8: France (Centre National de la Recherche Scientifique [CNRS])
First Year: The research of the node addressed mainly milestones 1,2,4,7,8;10,11,14,15,19
In the strong sector of the Standard Model, a framework (Resummed Chiral Perturbation Theory) has been developed to cope with potentially significant differences between the chiral limits

of two and three massless flavours and applied to the current data on low-energy $\pi\pi$ and πK scatterings [752, 753] (milestone 1). In order to determine strong low-energy coupling constants of the strong chiral Lagrangian within Resonance Chiral Theory, the two current approaches for spin one particles (vector and antisymmetric tensor) have been related to provide a more general class of effective Lagrangians [754, 755]. Two-loop three-flavour chiral perturbation theory has been investigated, with a determination of the η' contributions to the chiral low-energy constants, and a simplified representation for the pion mass [756] (milestone 2). Several aspects of hadron spectroscopy have been studied (milestone 4). An integral equation for the quark gauge invariant two-point Green's function was studied and solved in a well-defined approximation in order to yield the quarkonium spectrum [757]. The width of several η_b excitations into two photons has been determined using heavy-quark spin-symmetry, leading to model-independent relations [758]. In addition, hadron spectroscopy was considered in relation with lattice simulations. Baryon wave functions and diquark correlations were studied on the lattice in both the Coulomb and Landau gauge [759, 760]. The Δ-resonance parameters were proved to be obtainable from current lattice simulations [761]. Results were also obtained on the infrared behaviour of the gluon and ghost propagators in the Landau gauge, contradicting usual assumptions [762, 763].
In the weak sector of the Standard Model, an ongoing collaboration with DESY-Zeuthen node has provided lattice estimates for the Standard Model matrix elements relevant for neutral kaon mixing and those of electroweak penguin operators which give the dominant $\Delta I = 3/2$ contribution to direct CP violation in $K \to \pi\pi$ [759, 764]. Together with Univ. of Rome, an estimate of the $B \to K^*\gamma$ form factor has been obtained from quenched lattice simulations [765] (milestones 9 and 14). Several aspects of nonleptonic and semileptonic B decays have been covered (milestones 10 and 11). The question of isospin breaking in the yield of heavy meson pairs in e^+e^- annihilation near threshold has been studied for B-$\bar{B}$, D-$\bar{D}$ and K-$\bar{K}$ [766]. The problem of the Isgur-Wise functions to orbitally excited B mesons in B semileptonic decay to charm has been carefully formulated [767, 768]. Within a relativistic quark model, a relation has been found between the Light Cone Distribution Amplitudes and the Shape function of B mesons [769]. The parameters describing $B_{d,s}$-$\bar{B}_{d,s}$ mixing has been studied in and beyond the Standard Model, including both chiral corrections and the lowest-lying scalar heavy-light excitations, with significant implications for lattice extrapolations [770]. For penguin-mediated B-decays, in particular into $K^{(*)}\bar{K}^{(*)}$, the increasing information on B_d decay rates and CP-asymmetries can be used together with QCD factorisation and flavour symmetry to provide sharp SM predictions for B_s decays [180, 771]. A critical analysis of Bayesian statistics has been performed for the extraction of the CKM angle α, showing by both explicit calculations and frequentist approach that Bayesian statistics may lead to unphysical conclusions [772] (milestone 13).
Beyond the Standard Model, the signals of alternatives to supersymmetric models have been studied for different flavour processes (milestone 18). The $\Delta S = 2$ matrix elements required to study neutral kaon mixing in extensions of the standard model were calculated on the lattice [759, 764]. The implications of a single Universal Extra Dimension were worked out for FCNC B_s and Λ_b transitions [541] and rare $B \to X_s\tau^+\tau^-$ and $B \to K^{(*)}\tau^+\tau^-$ decays [773]. The implications of non-standard couplings of fermions to W and Z were analysed within the framework of effective theories, with a complete NLO analysis of experimental constraints on these modified couplings [774, 775] and a particular emphasis on the recent results obtained on

$K_{\ell 3}$ decays based on a dispersive representation [776–778] Constraints on new-physics contributions for $\Delta F = 2$ contributions were extracted from the available data within a Bayesian approach [540] (milestone 19).
Several reviews have been written, some on the complementarity between Chiral Perturbation Theory and lattice simulations [779, 780], others on $(g-2)_\mu$ [781, 782].
Second Year: The research of the node addressed milestones 2,4,5,7,10,11,14,15,16,19.
In the strong sector of the SM, the dispersive representation of scalar and vector $K\pi$ form factors has been investigated together with the KTeV collaboration exploiting data on $K_L \to \pi^\pm\mu^\mp\nu$ decays. The value of the scalar form factor at the Callan-Treiman point provides a stringent test of the Standard Model and allows for a comparison with the lattice QCD calculations. The dispersive representation of the scalar form factor has been matched to its expression at two loops in Chiral Perturbation Theory, providing further tests of this representation [783]. The vector form-factor $f_+^{K\pi}(t)$ was reconstructed thanks to analyticity, detailed experimental inputs on πK scattering in the P-wave and asymptotic constraints from QCD. The result was compared to new data on $\tau \to K\pi\nu_\tau$ decays [784]. Recent experimental and theoretical improvement on hadronic τ decays have allowed a reassessment of the value of $\alpha_s(M_\tau)$ using Finite-Energy Sum Rules, with a detailed comparison of the two main approach to treat the perturbative series for the Adler function [785]. The relations between dispersion relations and Chiral Perturabtion Theory have been investigated [786] and properties of the η-meson (decay constant, $\eta\pi$ scattering) have been studied in the framework of Resummed Chiral Perturbation Theory [787, 788]. A study of the properties of resonances with lattice simulations has been proposed, based on the finite-volume dependence of the energy levels [789, 790]. The integral equation for the two-point quark gauge invariant Green function has been studied in the more specific case of two-dimensional QCD in the large-N limit, allowing a numerical solution for the corresponding spectral functions [791]. Lattice computations were performed to extract moments of meson distribution functions [792] and nucleon and Δ masses [793] with $N_f = 2$ twisted mass fermions.
In the electroweak sector of SM, preliminary latttice results on the D-meson decay constant and $D \to \pi\ell\nu$ form factors with N_f=2 Wilson quarks [794]. The experimental data on $D \to K\ell\nu$ were exploited to extract the DD_s^*K coupling and to test various extrapolation scheme of form factors beyond the range experimentally accessible [795]. The QCD light-cone sum rules for $B \to \pi$ form factors has been reconsidered and updated with the inclusion of gluon radiative corrections to the twist-2 and twist-3 terms and updated input values [418]. The chiral corrections to the matrix elements of the $\Delta B = 0$ four-quark operators, relevant to the studies of the ratios of lifetimes of heavy-light mesons as well as to the power corrections to the inclusive semileptonic heavy-to-light decays, have been computed to help lattice extrapolations of these quantities [586]. $B \to K\eta(')$ decays have been studied within QCD factorisation, using the nonet symmetry to determine matrix elements of pseudoscalar densities for pseudsocalar mesons [796]. $B \to K\eta'$ predicetd branching ratios are 20-30% lower than experiment, a discrepancy solved if the $B \to \eta'$ form factor is increased by 40% with respect to the value according to the nonet symmetry. The radiative $B \to K\eta(')\gamma$ decays have also been studied in corners of the Dalitz plot where K or η mesons are soft where heavy meson chiral perturbation theory applies, with a good agreement with experimentally measured partially integrated rates [797].
Beyond the Standard Model, a Bayesian analysis was performed to combine the available exper-

imental information on B_s mixing,including the tagged analyses of $B_s \to J/\Psi\phi$ by the CDF and D0 collaborations. The resulting discrepancy with respect to Standard Model expectation is a hint of New Physics disfavouring Minimal Flavour Violation [563].

Third Year: During the time of this report, members of the node 8 have mainly worked on the tasks 1,3,5,6 concerning the strong sector of the Standard Model (SM), the tasks 7,10,11 of the SM electroweak sector and the tasks 14,18,19 for physics beyond SM.

Light flavours. A dispersive approach was used to construct fully relativistic model-independent representations of the η and K to three-pion decays, valid up to and including two-loop corrections [815–817]. In anticipation of new and more precise experimental measurements relevant for π^0 decays, chiral and QED corrections to these processes were considered [818, 819]. The robustness of the dispersive parametrization proposed for the scalar and vector $K\pi$ form factors has been studied. [820]. Using recently published, high-precision $\pi^+\pi^-$ cross section BABAR data by the BABAR, the lowest order hadronic contribution to the anomalous magnetic moment of the muon was reassessed, reducing the discrepancy between e^+e^- and τ-based results for the dominant two-pion mode [821].

B decays. Radiative B decays $B \to K\eta\gamma$ were analysed in the region where the emitted photon is energetic and one of the mesons is soft [822]. The issue of soft photons was reassessed for leptonic B decays, showing potential large corrections to the current determinations to the B decay constant from $B \to \ell\nu_\ell$ [823]. Several non-perturbative inputs for b decays have been studied either analytically or through lattice simulations: the Isgur-Wise functions at zero recoil $\tau_{1/2}(1)$ and $\tau_{3/2}(1)$, associated to $B \to D^{**}$ semileptonic decays [602], the Isgur-Wise functions for the heavy baryon Λ_b, related to the semileptonic decay $\Lambda_b \to \Lambda_c\ell\nu$ to be measured with precision at LHCb [824, 825], the 3-parton light-cone distribution amplitudes for heavy-light mesons [826, 827]. Other quantities related to the strong dynamics of heavy-light mesons have been computed from publically available gauge configurations: the coupling $\hat{g}$, parameterising in the Heavy Meson Chiral Perturbation Theory the $H^* \to H\pi$ transition [828], and the densities of charge, matter and axial charge of heavy-light mesons in the static limit [829].

CKM matrix and new physics. The decay constants f_K, f_D and f_{D_s} have been computed using gauge configurations produced by the ETM Collaboration, in good agreement with the unitarity of the CKM matrix [830]. Concerning global fits to the CKM matrix, models of new physics were investigated either through contributions to B^0-$\bar{B}^0$ mixing [831], or through charged Higgs contributions to $\Delta F = 1$ tree processes [606, 832].

Lattice methods. New actions and algorithms for lattice QCD with $N_f = 2 + 1$ flavors of sea quarks were used to to perform an ab initio calculation of light hadron masses [809, 833]. The contribution of excited states to 2-pts correlation functions was shown to be strongly reduced by computing a matrix of correlators and solving a generalised eigenvalue problem [834, 835]. A new approach to extract f_B and m_b from lattice simulations is based on the scaling law in $1/m_H$ of such quantities in the heavy quark limit [626].

Analytic methods. The links between perturbative series and non-perturbative corrections in QCD have been investigated using toy-models where the whole (divergent) perturbative series are known, like zero-dimensional ϕ^4 field theory [173]. Techniques for performing asymptotic expansions of perturbative Feynman amplitudes in either large or small ratios of kinematic variables were extended to cases with more than two scales and applied to large-order calculations

of the leptonic vacuum polarization contributions to the muon $g-2$ [70].
Reviews. Several reviews have been written in collaboration with other nodes, concerning τ-charm physics during the next few years at BES-III [246], flavour physics in the quark sector [112], the status of the theory and measurements of the muon anomalous magnetic moment [240,836]. Contributions to the activities of the Flavianet Lattice Averaging Group (FLAG) were also made, in particular the synthesis of light quark mass calculations and the writing of the corresponding section in the upcoming FLAG report.
Fourth Year: The members of Node 8 (France) have made progress concerning the following questions in the past year. In the strong sector of the Standard Model:

- We studied in detail various aspects of the renormalization of the spin-1 resonance propagator in the effective field theory framework [747] (task 1).

- We proposed new fitting formulae for the quark mass dependence of pseudoscalar masses, decay constants and $K_{\ell 3}$ form factors and applied them to recent unquenched lattice data to constraint the pattern of $N_f = 3$ chiral symmetry breaking [856] (task 2).

- We pointed out the limiations of renormalon models recently used in the litterature to model higher-order perturbation theory and discriminate between the methods for the determination of α_s using the tau spectral functions [857] (task 3).

- We studied the properties of the gauge invariant quark Green's function in two-dimensional QCD in the large N_c limit. An analytic and infrared finite solution of the exact integrodifferential equation defining the problem was possible to reach [858] (task 4).

- We determined the couplings of the Heavy Quark Effective Theory Lagrangian and heavy-light axial current, both expanded up to $1/m_b$, by matching few observables computed in HQET with their QCD counter-part [853], and we extracted from quenched lattice simulations the energy spectrum and the decay constants of the lowest B_s meson states [859–861]. (task 4).

- We studied the multidimensional Mellin-Barnes representation, a powerful tool to compute integrals of the "Feynman diagram"-type, leading to analytic continuation formulae for irreducible 2-fold Mellin-Barnes "master integrals" [173] (task 6).

In the electroweak sector of the Standard Model,

- We determined the ratio F_K/F_π in QCD with $N_f = 2 + 1$ flavors of sea quarks, based on a series of lattice calculations with three different lattice spacings, large volumes and a simulated pion mass reaching down to about 190 MeV [862] (task 7).

- We performed a chiral extrapolation of the RBC/UKQCD lattice data of the strangeness changing vector and scalar form factors and of the ratio of the kaon and pion decay constants within Chiral Perturbation Theory to two loops [147] (task 7).

- We reanalysed the KTeV K_{l3} data with a dispersive representation for the two $K\pi$ form factors, scalar and vector. The influence of the choice of the vector form factor parametrisation on the results for the scalar form factor was discussed [146] (task 7).

- We studied hadronic decays of the tau in exclusive channels using Resonance Chiral Theory: three-pion decay mode,the $KK\pi$ decay channel as well as $\tau \to (\pi/K)^-\gamma$ and $\tau \to \eta^{(\prime)}\pi^-\pi^0\nu_\tau$ [150, 151, 256] (task 7).

- We reconsidered the dispersive representation of $\gamma\gamma \to \pi\pi$ and its application to analyze the new experimental measurements by the Belle collaboratio, and to deduce values of the pion dipole and quadrupole polarizabilities and the related chiral coupling constants [863] (task 8).

As far as physics beyond the Standard Model is concerned:

- We proposed two applications of the production of correlated $D\bar{D}$ pairs at BESIII, based on the angular information contained in subsequent $D \to VV$ decays, to help in the determination of the CKM matrix angle γ and the identification of new physics CP-violating effects [864] (task 16).

- We discussed different ways of extending the concept of Minimal Flavour Violation for leptoquarks, and discussed the most promising discovery channels in each case [865] (task 18).

- We analysed the recent Tevatron results on neutral meson mixing in combination with other flavour observables within the CKMfitter statistical framework, showing evidence of New Physics in $\Delta F = 2$ transitions. We analysed the resulting constraints in a model-independent parametrisation, within three different scenarios [521] (task 19).

Node No. 9: Switzerland (Universität Bern [UBERN])
First Year: The research of the node addressed milestones no. 1,2,3,5,14,15 and 18, which span the topics of all working groups. Experience with the Domain Decomposition Hybrid Monte Carlo (DD-HMC) algorithm was extended over a wide range of parameter values [866, 867]. Lattices of sizes 48×24^3 and 64×32^3, with lattice spacings from 0.05 to 0.08 fm, were simulated at sea-quark masses as light as 20–25 MeV, using the Wilson (and Wilson non-perturbative improved) quark actions. Masses and pseudoscalar constants of the light mesons were computed and a dependence on the light-quark mass very much as predicted by chiral perturbation theory was obtained (milestone 2 and 3).
In [8] a general method to perform the matching of chiral $SU(2) \times SU(2)$ to $SU(3) \times SU(3)$ at two-loop order was developed and applied to the low energy constants at order p^4. This will be of relevance for the lattice community (milestone 2).
An isospin breaking part in the decay K_{e4} which was overlooked so far has been identified. It brings theory and K_{e4} experiment performed by the NA48/2 collaboration at CERN into agreement (milestone 1).

The NA48/2 members of our node have: made an analysis of the charged kaon data collected in 2003 and 2004; accumulated a large $O(10^5)$ sample of $K \to e\nu$ events; performed R&D work towards the realisation of an experiment to measure $K^+ \to \pi^+\nu\bar{\nu}$ at the SPS.
The NNLL matrix elements of the dipole operator in the $\bar{B} \to X_s\gamma$ decay have been calculated. This, combined with other calculations at NNLL precision, led to the first NNLL prediction of the $\bar{B} \to X_s\gamma$ branching ratio which increased the high sensitivity of this observable to new physics significantly [659] (milestone 15). In [868] the charm quark mass dependence of the matrix element associated with the electromagnetic dipole operator was calculated. This was a missing ingredient for the NNLO branching ratio for $B \to X_s\gamma$. NNLO corrections to the hard-scattering kernels entering the QCD factorization formula for $B \to K^*\gamma$ were also computed [869], deriving complete results for the dipole operators O_7 and O_8, and partial results for O_1 valid in the large β_0 limit. Large perturbative logarithms in the hard-scattering kernels were identified and resummed using soft-collinear effective theory. (Milestone 14 and 15).
The physics case of a Super Flavour Factory has been discussed in [29].
The supersymmetric large $\tan\beta$ corrections to $\Delta M_{d,s}$ and $B_{d,s} \to \mu^+\mu^-$ have been revisited [870] (milestone 14), and a bound on minimal universal extra dimensions from $B \to X_s\gamma$ derived [871] (milestone 18). In [872] it has been pointed out that the precision measurements of the $Z \to b\bar{b}$ pseudo observables imply that in models with minimal-flavor-violation the sign of the flavor-changing Z-penguin amplitude is identical to the one present in the standard model.
The estimation of the rare K-decay matrix elements from $K_{\ell 3}$ experimental data is extended beyond leading order in Chiral Perturbation Theory and the uncertainties on the $K^+ \to \pi^+\nu\bar{\nu}$ and $K_L \to \pi^0\nu\bar{\nu}$ matrix elements are reduced by a factor of about 7 and 4, respectively, and similarly for the direct CP-violating contribution to $K_L \to \pi^0\ell^+\ell^-$ [873] (milestone 14).
Second Year: The research of the node addressed milestones no. 1,2,3,6,7,12,13,14,15 which span the topics of all working groups. In [869] the exclusive rare decays $B \to V\gamma$ have been analyzed. In particular the hard-scattering kernels of O_7 and O_8 were calculated at NNLO, approximations for the O_1 contribution were included and phenomenological consequences were discussed. Virtual and Bremsstrahlung fermionic corrections to the $(O_7, O_8)-$ interference which contribute to the branching ratio for $B \to X_s\gamma$ at NNLL level were analyzed in [882].
Using the published KTeV samples of $K_{L\,e3}$ and $K_{L\,\mu 3}$ decays, an analysis of the scalar and vector form factors based on the dispersive parameterization is performed. The correlations between the two form factors are studied in detail [568, 783].
The evaluation of the radiative corrections to all four $K \to 3\pi$ decays in the framework of NR effective field theory has been finalized [883]. The code has already be implemented by the NA48/2 collaboration in their data analysis.
Supersymmetric extensions of the standard model with minimal flavour violation (MFV) have been studied. In [884] it has been shown that requiring MFV is enough to protect the proton from decaying, without having to introduce the R-parity symmetry. In [885] the running of these models has been analyzed in detail and it has been shown that the MFV parameters display a quasi fixed-point behaviour.
The NA48/2 members of our node have completed the analysis of the 2003 data set of $K^\pm \to \pi^\pm\gamma\gamma$, and have delivered a measurement of the branching ratio and the $\hat{c}$ coupling constant of χPT.

Third Year: The research of the node addressed milestones no. 1,2,3,6,7,10,11,13,14,15, 18 which span the topics of all working groups.
In [886] an analysis of $K^{\pm} \to \pi^{\pm}e^{+}e^{-}(\gamma)$ decays based on a sample of 7253 candidates with 1% background contamination has been presented. The branching ratio in the full kinematic range was measured, and the shape of the form factor determined. A possible CP violating asymmetry of K^{+} and K^{-} decay widths was investigated, and a conservative upper limit of 2.1×10^{-2} at 90% CL was established.
In [887] we have analyzed isospin breaking corrections to the $\pi\pi$ phase shifts extracted from K_{e4}-decay measurements and shown that these are very important at the level of precision reached by current experiments. Once these are taken into account, the previous discrepancy between NA48/2 data on K_{e4} decays and the prediction of $\pi\pi$ scattering lengths disappears. In [888] we have worked out, for the coupling constants which occur at order p^6, the dependence on the strange quark mass at two-loop accuracy, completing an earlier work on the $O(p^4)$ constants.
In [889] we derived analytic results for the high invariant mass region of the lepton pair in the inclusive rare decay $B \to X_s\ell^{+}\ell^{-}$. In particular, we calculated the two-loop matrix elements associated with the operator O_2 in this region, using the method of differential equations and the method of regions. In [456] we published the first NNLO prediction for $B^{-} \to \pi^{-}\pi^{0}/\rho^{-}\rho^{0}$. Confronting our results with experimental data we found strong support for QCD-factorization. In [890] we studied the impact of NNLO corrections on partial decay rates in $B \to X_u\ell\bar{\nu}_{\ell}$ transitions at leading order in the $1/m_b$ expansion in the shape-function region. We found that these corrections induce significant downward shifts in the central values of these partial decay rates, leading to an increase of $|V_{ub}|$ by slightly less than 10%. Within the physics workshop on SuperB, specific differences between a $10fb^{-1}$ and a $50fb^{-1}$ SuperB factory have been analyzed [123]. Bounds on flavour-violating gluino and squark decays have been derived from the present flavour data [891].
Perhaps the clearest evidence for the breaking of chiral symmetry is provided by the condensation of the low modes of the Dirac operator. As shown in [892], many spectral observables are renormalizable and thus provide new opportunities for qualitative and quantitative studies of the chiral regime of QCD in a field-theoretically solid framework. In [893] the low lying spectrum of QCD in the delta-regime has been calculated in chiral perturbation theory up to NNL order. The spectrum has a simple form in terms of the pion decay constant F and a combination of low energy constants. The result should help a precise determination of these parameters to good precision.
In [820] we have built a dispersive representation for the normalized vector form factor and performed a careful analysis of all the hadronic uncertainties. The $\tau \to K\pi\nu$ data from BaBar and Belle have been used in this respect. In [112] a summary of the status of quark flavour physics on the theoretical and experimental sides has been done. Within the Kaon working group we have reviewed the determination of the CKM matrix element $|V_{us}|$ and the stringent tests of the Standard Model which can be performed with kaon decays.
In [497] the CP-violating phenomenology of the MSSM with Minimal Flavor Violation (MFV) in the lepton sector has been revisited and carefully analyzed. In [894] a natural implementation of Dirac neutrinos naturally without the extreme fine-tuning problems within the warped extra-dimensional scenario proposed by Randall and Sundrum was proposed. A generic parameter

space where lepton sector constraints are naturally satisfied at the few TeV scale, while simultaneously reproducing the observed lepton mass and mixing patterns has been found.
Fourth Year:

- Together with node 4 and external collaborators, the Swiss node finished a project on the $(O_7, O_8)-$interference contribution to $B \to X_s\gamma$ at NNLO in QCD [510]. The Swiss node and node 4 (Karlsruhe) were also involved in the computation of SUSY-QCD corrections to the gluino induced contribution to $b \to s\gamma$. The results will be published within the next few months.

- Possible correlations between low-energy flavour and high-p_T observables in supersymmetric models have been explored: squarks can have large flavour-violating decay modes which are compatible with the present data from flavour physics [911].

- New observables in the exclusive decay $\bar{B} \to \bar{K}^{*0}\ell^+\ell^-$ in which any formfactor dependence cancels out at leading order level [912, 913]. Together with several other nodes the physics case of Super-B factory has been discussed [159].

- The decay $\eta \to 3\pi$ has been analyzed on the basis of a dispersive treatment. The aim is to extract a reliable estimate of the quark mass ratio Q from the measurement of the decay rate [172].

- Finite volume effects have been studied for heavy particles like nucleons or heavy mesons [751], and for pions at finite lattice spacing for twisted-mass QCD [914].

- The gradient flow in non-abelian gauge theories has some remarkable and perhaps unexpected properties [915]: in particular, it maps the fundamental gauge field to a smooth renormalized field and may therefore be used to study these theories from short to long distances. Some new insight can be gained into the possible causes of the rapid slowing-down of current QCD simulations when the lattice spacing is reduced [916].

- Global symmetries of the Yang-Mills theory on the lattice have been exploited to design a new computational strategy for extracting glueball masses and matrix elements which achieves an exponential reduction of the statistical error with respect to standard technique. The topological susceptibility for the SU(3) Yang-Mills theory is computed in the continuum limit with a precison of about 2% by using the definition of the charge suggested by Neuberger fermions for two values of the negative mass parameter s.

- The first paper of the FLAVIAnet Lattice Averaging Group (FLAG), providing a review of lattice results concerning low-energy particle physics has been published just after the end of the FLAVIAnet period. The paper condenses the activity of members of several different nodes and of more than two years of work and represents one of the successes of the network.

Node No. 10: Austria (Universität Wien [UNIWIEN])

First Year: The research of the node was related to the topics of working groups no. 1,2 and 4. The work of the Viennese group of this node addressed milestones no. 1,2,7, and 8: In [917] we have completed the analysis of meson resonance contributions to chiral low-energy constants of order p^4 by including all quark-antiquark bound states with orbital angular momentum ≤ 1. In [7] it was shown that the number of previously known terms in the mesonic chiral Lagrangian of order p^6 in the two-flavour sector can be reduced by at least one from 57 to 56 by providing an explicit relation among the operators. The progress in determining coupling constants of mesonic chiral Lagrangians was reviewed in [918]. A discussion of isospin violating effects in the scalar form factors of $K_{\ell 3}$ decays and a detailed numerical analysis of electromagnetic contributions to $K_{\mu 3}$ decays have nearly been completed. The papers of the Slovenian branch of this node were related to milestones no. 10,11,13,14 and 15: Motivated by recent experimental results on charm physics, the implications of the updated constraints on new physics in rare charm meson decays have been investigated [919]. In [710] we have calculated chiral loop corrections for the weak decays of B meson to positive and negative parity charmed mesons within a framework which combines heavy quark and chiral symmetries. The impact of the lowest-lying positive parity heavy mesons on the determination of the Isgur-Wise functions was also investigated. A review on D-meson physics was published in [920] and recently a PhD-thesis on the role of resonances in heavy meson processes within the standard model and beyond [921] was finished. Using soft-collinear effective theory, all semi-inclusive hadronic $B \to XM$ decays (an energetic light meson M recoils against an inclusive jet X) near the endpoint were desribed at leading order in $1/m_b$ in [922]. The present status of the determination of unitarity triangle angles was reviewed in [923, 924]. Possibilities of probing minimal flavour violation at the LHC were discussed in [925].

Second Year: In the second year, the research of the node was related to the topics of working groups no. 1,2,4,5.

The work of the Viennese group of this node addressed milestones no. 1,2,7: Using chiral perturbation theory, large N_c estimates for the determination of low-energy couplings and dispersive methods, we have discussed the standard model predictions for the scalar form factors of $K_{\ell 3}$ decays [926]. Our analysis includes a discussion of isospin violating effects of strong and electromagnetic origin. The radiative corrections to all $K_{\ell 3}$ modes to leading non-trivial order in chiral effective field theory have been calculated [927], working with a fully inclusive prescription of real photon emission. New results for the $K_{\mu 3}$ modes were obtained and previous results on the K_{e3} modes were updated, providing an important theoretical input for the extraction of the CKM matrix element V_{us} from $K_{\ell 3}$ decays. A paper on the dispersive approach to chiral perturbation theory has recently been completed [786]. These methods are presently applied in an investigation of cusp effects in $K \to 3\pi$ decays.

The papers of the Slovenian part of this node were related to milestones no. 4,11,13,14,15,18,19: The chiral corrections to the matrix elements of the $\Delta B = 0$ four-quark operators which are relevant to the studies of the ratios of lifetimes of heavy-light mesons as well as to the power corrections to the inclusive semileptonic heavy-to-light decays where determined in [586]. The Dalitz plots of the decays $B \to \eta K\gamma$ and $B \to \eta' K\gamma$ were investigated in [797], using the combined heavy meson, large energy, and chiral Lagrangian theories. Motivated by the possible

sensitivity to the presence of new physics in $B_q \to D_q \tau \nu$ decays, we have investigated the effects of chiral corrections to the relevant (scalar) form factor [585]. The explicit chiral behaviour of the computed chiral corrections can be used to guide future lattice computations in approaching the physical regime for the light quark masses. In [928], a constraint on the CKM quark mixing parameters $\bar{\rho}$ and $\bar{\eta}$ was obtained from $B \to K^+\pi$. In [587] we investigate the Yukawa sector for up-like quarks in Lee's version of the littlest Higgs model. We derive general quark mass and mixing formulae and study leading order contributions due to non-zero light quark masses. Relying on the unitarity of the generalized quark mixing matrix we obtain corrections to the CKM matrix elements. In this model, flavour changing neutral currents appear at the tree level. Predictions for x_D, $D \to \mu^+\mu^-$ and the $t \to c(u)Z$ transitions are discussed. A detailed review of the potential of a Super Flavour Factory (SFF) for searches of new physics was presented in [929]. The SFF is envisioned to be a crucial tool for essential studies of flavour physics in the LHC era.

Third Year: The work of this node addressed milestones no. 1,2,7,8,11,18, spanning the topics of working groups 1,2,4,5.

Using more precise experimental data and improved knowledge of low-energy constants, the impact of isospin violation for extracting the s-wave $\pi\pi$ scattering phase shifts from $K \to \pi\pi$ decays has been re-analized [85]. The status of chiral perturbation theory in the meson sector was reviewed in [930], with the main emphasis on recent developments in pion pion scattering, semileptonic decays and nonleptonic kaon decays. A contribution covering $P_{\ell 2}$ and $P_{\ell 3}$ ($P = \pi, K$) decays to the extensive review on "Flavor Physics in the Quark Sector" [112] was written. The dispersive approach to chiral perturbation theory was applied in an investigation of cusp effects in $K \to 3\pi$ [817] and the $\eta \to 3\pi$ decay [816].

The chiral loop corrections to the B meson decay amplitudes to positive and negative parity charmed mesons were calulated in [607]. It was found that corrections due to states of opposite parity are competitive with the contributions arising from K and η meson loops.

It was noticed recently that among many scenarios of new physics, leptoquarks might compensate for the disagreement between lattice and experimental results for the charmed strange meson decay constant. The leptoquarks might also modify the flavour changing neutral current charm decays. Studies related to this question were performed in [931] and [608]. Using the most general model independent Lagrangian, possible experimental signals of new physics in $t \to c(u)\ell^+\ell^-$ FCNC top decays were investigated [631].

The observed mass pattern of scalar resonances below $1\,\mathrm{GeV}$ suggests a tetraquark assignement over the conventional $\bar{q}q$ assignement for these states. This question was explored in a recent lattice study [932]. No indication for light tetraquarks at the pion mass range $344\,\mathrm{MeV} - 576\,\mathrm{MeV}$ was found. This does, however, not exclude the possibility of finding tetraquarks in a simulation with smaller pion masses or a different interpolator basis.

Fourth Year: The work of this node addressed milestones no. 1,2,5,7,8,11,18, spanning the topics of working groups 1,2,4,5.

The Vienna group has contributed to a global analysis [144] of leptonic and semileptonic kaon decay data, including all data of recent experiments. This analysis, in conjunction with precise lattice calculations of the hadronic matrix elements now available, leads to a very precise determination of V_{us} and allows stringent tests of the Standard Model. Further members of this group

have also contributed to a review article on physics with the KLOE-2 experiment at the upgraded DAΦNE [128].
Analytic approximations of chiral $SU(3)$ amplitudes for the extrapolation of lattice data to the physical masses have been proposed in [936]. The method allows the determination of NNLO low-energy constants in a controllable fashion. The approach was tested with recent lattice data for the ratio F_K/F_π of meson decay constants.
A new algorithm for obtaining the effective continuum threshold in vacuum-to-boundstate correlators was formulated in [937]. These correlators are the basic objects for the calculation of hadron form factors in the method of light-cone sum rules in QCD. The application of the new algorithm considerably enlarges the range of the momentum transfer where the form factor may be extracted from the correlator. In [938] the extraction of the ground-state decay constant from the two-point correlator in QCD and in potential models are compared. The results suggest that in QCD a Borel-parameter dependent threshold leads to a more reliable and accurate determination of bound-state characteristics by the method of sum rules. These methods were subsequently applied to the determination of the decay constants of heavy pseudoscalar mesons from QCD sum rules [939].
A large part of the studies performed by the Slovenian group of this node was devoted to physics beyond the Standard model: Lepton flavour violation in the presence of a low-scale seesaw of type I + III was studied in [630]. The importance of flavour effects in models where leptogenesis proceeds via the decay of Majorana electroweak triplets was analyzed in [940].
The measured forward-backward asymmetry in the $t\bar{t}$ production at the Tevatron might be explained by the additional exchange of a coloured weak singlet scalar which appears in some grand unified theories. The phenomenological consquences of such a scenario were analyzed in two recent publications [941, 942].
The contributions of non-standard tbW effective operators to the decay of an unpolarized top quark into a bottom quark and a W gauge boson at next-to-leading order in QCD were discussed in [943].
The viability of generic Higgless models at low energies was investigated [653] imposing constraints from electroweak precision observables and unitarity constraints up to the TeV scale. The analysis showed that a consistent picture can be obtained by introducing a single vector state (with a mass below 1 TeV) and an axial state with $1.2m_V \leq m_A \leq 1.4m_V$.
Within the Standard Model, the tree-level contributions to the rare decays $B^+ \to \pi^+\nu\bar{\nu}$, $B^+ \to K^+\nu\bar{\nu}$ and $B^+ \to K^{*+}\nu\bar{\nu}$ were analyzed and compared to those occurring in $K^+ \to \pi^+\nu\bar{\nu}$, $D^+ \to \pi^+\nu\bar{\nu}$ and $D_s^+ \to \pi^+\nu\bar{\nu}$. It was found that the tree-level contributions account for 98%, 12% and 14% of the total $B^+ \to \pi^+\nu\bar{\nu}$, $B^+ \to K^+\nu\bar{\nu}$ and $B^+ \to K^{*+}\nu\bar{\nu}$ rates, respectively.
The Standard Model predicts highly suppressed flavour changing neutral current processes of the top quark ($t \to cV$, $V = Z, \gamma, g$), while new physics in many cases lifts this suppression. The branching ratios of these rare decays mediated by effective flavour changing neutral current couplings at next-to-leading in QCD were calculated [944, 945], including the effects due to operator mixing.
A search for signals of weak annihilation in inclusive D decays was presented [946]. Both the widths and the lepton energy moments, which are quite senstive probes, were considered. The analysis of Cleo data showed no clear evidence of weak annihilation and allowed to put bounds

on their relevance in charmless B semileptonic decays.
It was shown [947] that the ratios of tree and penguin amplitudes in $B \to K^+\pi$ and $B \to \rho K$ are 2 to 3 times larger than in $B \to K\pi$. This allows for considerably larger CP asymmetries in the former processes than the 10 % asymmetry measured in $B^0 \to K^+\pi^-$.
The question whether the lightest scalar mesons σ and κ contain a large tetraquark component $\bar{q}\bar{q}qq$ was investigated [948, 949]. A search for possible light tetraquark states with $J^{PC} = 0^{++}$ and $I = 0,\, 2,\, 1/2,\, 3/2$ was performed. Apart from the lowest scattering states, additional light states in the in the $I = 0$ and $I = 1/2$ channels were found, which can be interpreted as the observed resonances σ and κ with a sizable tetraquark component.
In [950], the pion quark-wavefunctions in the Nambu-Jona-Lasinio model and in quenched lattice QCD were examined. It turned out that the results agree remarkably well in all channels.

Node No. 11: Germany–North (Stiftung Deutsches Elektronen Synchrotron [DESY])
First Year: The research of the node has largely concentrated on working groups 4 and 5 with influence on working groups 1,2,3. Work has been carried out to reach milestones no. 2–4, 7–9, 11, 14–18.
Open questions in D–meson semileptonic decays have been discussed and the necessary steps needed to answer them have been identified [768]. The isospin and $SU(3)$ breaking, as well and electromagnetic interactions in the Chiral Perturbation Theory (ChPT) with the strange quark have been extensively studied [953–955] and very useful reviews on ChPT and hadronic atoms have been published [780, 956, 957]. Moreover, we propose an effective field theory framework for the extraction of the S-wave $\bar{K}N$ scattering lengths from the simultaneous analysis of the experimental data on kaonic hydrogen and kaonic deuterium spectra. The determination of mass and width of the Δ resonance from a computation of the energy spectrum in a finite volume by means of lattice QCD has been explored.
In relation to many milestones, lattice gauge theory formulation and methodology has to be refined as a major activity. In particular ChPT including lattice spacing effects has been studied [958–960], which is relevant for reaching milstones 2–4 and an automation of perturbation theory in the QCD-coupling on the lattice has been pursued [961] with a particular eye on the determination of α_s (milestone 3). Domain wall fermions were investigated perturbatively [962] and numerically [963]. The twisted mass formulation of lattice QCD was investigated [538] and applied to extract light quark masses and strong low energy constants in the $N_f = 2$ theory [14, 15] (milestones 2,3). Also the determination of $|V_{us}|$ from leptonic Kaon decay rates was pursued (milestone 7). The non-perturbative renormalization of four-fermion operators for K-physics [964] and B-physics [965] provides a basis for future determinations of B-factors in the systems. In a preparation for many applications in B-physics, HQET on the lattice has been developed and refined [412, 965–970] and reviewed for a larger community [971]. Work on the non-perturbative renormalization [968] of spin-dependent heavy quark potentials and the computation of the bare potentials on the lattice [972] has provided input for WG3.
Second Year: The non-relativistic effective Lagrangian approach has been applied to study of $K_L \to 3\pi$ and $\eta \to 3\pi$ decays [981]. The possibility of extracting $\pi\pi$ scattering lengths from these decays has been investigated. The approach has been further extended to include electro-

magnetic effects in the charged as well as neutral kaon decays [883]. The treatment of unstable states and the extraction of phase shifts in lattice QCD have been studied by using effective field theory methods in a finite volume [789, 790, 977]. Nucleon-nucleon scattering at next-to-leading order in chiral EFT is analysed on the lattice. Using the same method, the properties of neutron matter close to the unitarity limit are worked out [982, 983].
The twisted mass formulation of lattice QCD was applied in [793] for the computation of the light baryon masses and to charmed mesons [984], while in [52] the simulation and analysis details of a prior publication [15] were given. In [985] new results concerning the spectrum of QCD with one quark flavor were presented; a summary was given in [986].
Variants of applying non-perturbative HQET on the lattice for precision B-physics have successfully been tested in quenched computations [298, 987, 988]. Preparations for their application with two flavours of dynamical fermions have been carried out [989, 990]. The renormalization and improvement of the light quark sector of the two flavour theory was investigated [991, 992].
Lattice spacing effects in pion scattering have been included in the chiral perturbation expansion [993]. Wilson fermion simulations with "nHYP smearing" have been applied in the epsilon regime [994] with a new reweighting technique to reach very small quark masses [995].
Third Year: Using the maximally twisted mass formulation of lattice QCD, it became possible to obtain a number of important simulation results within the European Twisted Mass Collaboration (ETMC). There have been results on the pion scattering length [1020], a new proposal for B-physics has been given [626], Meson masses and decay constants could be determined [1021], pseudoscalar decay constants of kaon and D-mesons have been computed [602], precise calculations of low energy constants were obtained [1022], the static-light meson spectrum was computed [1023]. The eta' meson was studied [1024] and simulations with dynamical strange and charm degrees of freedom have been started [113].
Various techniques for future high precision lattice flavour physics computations have been developed [834, 1025, 1026] and new fermion formulations have been investigated in perturbation theory [1027, 1028]. In particular the matching of Heavy Quark Effective Theory and QCD has been advanced in the theory with two dynamical flavours [346] and a new computation of the decay rate for D_s into leptons has been initiated [1029, 1030]. Also the moving NRQCD formulation for lattice computations of decays of hevay-light mesons was investigated [1026, 1031].
Dynamical properties of the Hybrid Monte Carlo algorithm, which is used for the Monte Carlo Simulations of lattice gauge theories, were studied [1032]. Non-perturbative determinations of relativistic corrections to the inter-quark potential from lattice QCD [1033] provide input for working group 3.
The work of [1034, 1035] opens a promising possibility for the determination of chiral perturbation theory low energy constants (WG1/4).
The papers [1036, 1037] deal with the use of the effective field theories to analyze the lattice data [1036, 1037], in particular, the fourth-order ChPT calculation (with explicit Δ degree of freedom) of the finite-volume corrections to the spectrum of QCD in the channel with quantum numbers of the Δ-resonance [1036]. Lüscher approach has been generalized to the two-particle elastic scattering and a method of calculating $\bar{K}N$ scattering lengths in lattice QCD has been suggested [1037]. Hadronic atoms, in particular kaonic deuterium are studied in [898, 1038].
The cusp structure of the $\eta \to 3\pi$ decay amplitude is investigated up to two loops in the non-

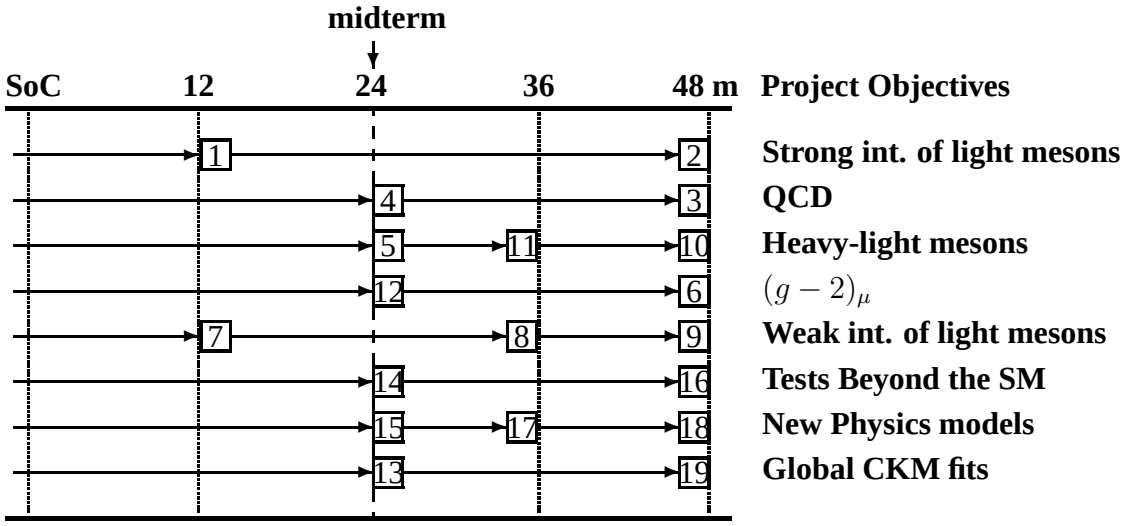
relativistic effective field theory [1039] and also electromagnetic corrections relevant for the extraction of light quark mass ratios have been calculated [1040].
In Ref. [887], it is demonstrated that isospin-breaking corrections play an important role in the extraction of the S-wave $\pi\pi$ scattering lengths from the experimental data on K_{e4} decays.
The non-relativistic effective Lagrangian approach has been applied to study the decay $\eta' \to \eta\pi\pi$, investigating the possibility to extract information on $\pi\pi$ and $\pi\eta$ threshold parameters [1041].
Isospin-breaking corrections to the pion–nucleon scattering lengths, both of strong and electromagnetic origin, are an essential ingredient in particular to the extraction of these quantities from pionic hydrogen; these have been calculated completely to third order in the chiral expansion [1042]. Also above threshold, these effects have been shown to remain moderate [1043].
Meson–baryon scattering lengths have been calculated in covariant baryon chiral perturbation theory to third order [1044]. The matching between the three- and the two-flavor theory has been performed for all dimension-two constants, and new low-energy theorems have been derived for pion–hyperon scattering.
Fourth Year: We extracted low energy constants of the effective chiral Lagrangian and derived quantities, such as the light quark mass, with high precision, using maximally twisted mass fermions for two mass-degenerate quark flavours [132]. We used four values of the lattice spacing, spatial lattice extents ranging from 2.0 fm to 2.5 fm and pseudo scalar masses in the range 280 MeV to 650 MeV and extrapolated to the continuum and infinite volume limits. First results are also obtained with 2+1+1 dynamical quarks [154, 169]. In the used formulation of lattice QCD, systematic effects due to isospin breaking were investigated with the help of the associated low energy effective theory [1087]. Also an alternative to extract low energy constants was studied [1088] and seen to be feasible. It uses lattice simulations in the epsilon regime.
The non-perturbative improvement and renormalization of the quark mass in O(a)-improved lattice QCD is determined [366] and it is applied in a comprehensive test of HQET, a publication which is presently being finished. In a series of papers [859, 860, 1082] a fully non-perturbative treatment of HQET including $1/m$ corrections was carried out for the first time. This lattice gauge theory computation is in the quenched approximation but the continuum limit is taken. The quark mass [860], the spectrum [859] and the B_s decay constant [1082] (including the excited state) are computed with good precision. It turned out that the $1/m_b$ corrections are very small. In the next couple of years, these techniques will be applied including the effects of dynamical fermions. Ref. [366] is an intermediate step and first results for physics observables have been presented at this years lattice conference.
A chiral perturbation theory investigations estimates the quark-disconnected diagrams contibuting to the hadronic vacuum polarisation for the Muon g-2 [1081]. It will help to complement lattice efforts, where the quark-disconnected contributions have comparatively large statistical errors.
An important source of uncertainties in lattice gauge theory computations is the autocorrelation present in the "measurements" at different Monte-Carlo times from the same Markov chain. The associated critical slowing down of QCD simulations was analysed in detail [1032, 1083] and an improved error treatment was found.
The strong coupling at high energy scale is an important input parameter for many analysis in flavour physics and QCD in general. Its determination from lattice gauge theory through a

recursive finite size technique is particularly clean and perturbative uncertainties can be reduced to a minimum. The running of the coupling in the Schrödinger functional scheme was non-perturbatively computed with four massles quarks – a milestone on the way to the desired 5-flavour coupling at the Z-scale, since the b-quark represents a small effect which can safely be incorporated by perturbation theory.
The electric dipole form factors of neutron and proton have been studied in U(3) chiral perturbation theory at next-to-leading order [1074]. In particular, improved results for chiral extrapolation of lattice results are discussed.
The Lüscher formalism has been generalized to study the extraction of the resonance matrix elements on the lattice [1075]. In particular, assuming that the effective range expansion is convergent in the resonance region, a procedure for the extraction of the resonance pole position on the complex plane is discussed. It is shown that, applying essentially the same procedure in the presence of the external field, it is possible to extract the resonance formfactor at the zero momentum transfer in a finite-volume. A high-accuracy calculation of π^-–deuteron scattering at threshold allows for the most precise determination yet of the pion–nucleon scattering lengths from a combined analysis of pionic hydrogen and pionic deuterium atoms [1076].
In [1077], a procedure for the extraction of the resonance parameters on the lattice, alternative to Lüscher's approach has been proposed. In particular, it is shown that in the presence of an isolated low-lying resonance the Euclidean two-point function displays an universal behavior characterized by the energy and width of the resonance. Consequently, the latter can be extracted directly from the fit of the measured two-point function at finite (not asymptotically large) times.
We have calculated radiative corrections to the flavor-changing neutral current process $K \to \pi\ell^+\ell^-$ [1078]. The validity of the soft-photon approximation as well as the necessity of additional phase space cuts for the electron–positron final states are discussed in detail.
We use non-relativistic effective field theory to analyze the effects of pion–pion final-state interactions on the Dalitz plot parameters of $\eta \to 3\pi$ decays [1079]. For the slope parameter of the neutral channel, we find $\alpha = -0.025 \pm 0.005$, in marginal agreement with experiment. We point towards a possible inconsistency between neutral- and charged-channel Dalitz plot parameters as experimentally determined by KLOE.
The custodial Randall-Sundrum Model has been investigated in detail [1089,1091]. A systematic factorization analysis has been performed for the $\bar{B} \to X_s\gamma$ photon spectrum in the endpoint region $m_b - 2E_\gamma = \mathcal{O}(\Lambda_{\rm QCD})$ [1090]. The determination of V_{ub} from $B \to X_u l\nu$ decays has been improved by including NNLO QCD corrections [890].
Members of the node participate in the Flavianet Lattice Averaging Group which is presently finishing its first report.

1.2 Assessment of the milestone tasks

In our network proposal we have foreseen the following schedule for the completion of the milestone tasks shown in Tab. 4. By the time of the midterm review, the milestone tasks no. 1,4,5,7 and 12–15 had been completed and a brief summary of the corresponding research achievements can be found in our midterm report. Now, by the end of the network, all other milestones have been reached as well. Often new scientific aspects not foreseen by the inception of the network

Table 4: FLAVIA*net* Schedule and Milestones [SoC=Start of Contract, m=months].



have arised and were addressed by our research as well. In the narrative description of our research in Sect. 1.1 we have put our published scientific results into the context of the milestones.

2 Publications

The FLAVIA*net* members wrote the scientific papers listed below during the 4-year funding period of the network. Only papers which are published in a refereed journal or submitted for publication are listed with one exception: In the case of our ESR and ER we also list unrefereed papers. We list joint publications involving several FLAVIA*net* nodes in Sect. 3.8.

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368 out of the listed 1141 publications involve at least two different nodes of FLAVIA*net*. These results of our networking activity are listed in Sect. 3.8 in the form of matrices. 142 of the listed papers involve one of our ESR or ER. Tables with ESR/Er and their publications can be found in the annual reports.

3 Conferences, Workshops and General Networking

The FLAVIA*net* nodes have organised several events devoted to common research and scientific exchange. The major meetings were the five *Euro-Flavour* conference in Barcelona, Orsay, Durham, Bari and Munich. These conferences are described in the following subsections. Sect. 3.6 summarises other conferences and workshops organised at one of the nodes, if they were totally or in part devoted to flavour physics. Sect. 3.7 is devoted to other conferences and workshops, with focus on the talks given by the ESR and ER funded from the network.
In Sect. 3.8 we summarise the individual networking activity related to research. Finally we justify changes to our original schedule.

3.1 Euro-Flavour 06

The conference *Euro-Flavour06* was the Inaugural Workshop of the European Flavour Physics Network FLAVIA*net*. It took place in Barcelona in Casa de Convalescencia from the 2nd to the 4th of November of 2006. The meeting was organized by M. Jamin and J. Matias, from node no. 2. The main topics of the meeting correspond to the subjects of the six working groups within FLAVIA*net*, namely:

- Kaon decays

- B–physics
- Tau–charm and quarkonia
- Analytic approaches to QCD
- Lattice methods
- Radiative return and Monte Carlo tools

There were a total of 77 participants (about one quarter of them were students) and 29 plenary talks. On Friday afternoon we organized six parallel sessions, one per each working group to discuss specific topics of each field. Most of these talks were presented by students and postdocs. Discussions in Kaon physics WG1 focused on the future of Kaon Physics at CERN and $K \to 3\pi$, B physics WG2 focused on the decays $B \to K^*\gamma$, $B \to \pi K$ and $B_s \to KK$, Tau-charm and quarkonium physics WG3 focused on the open problems in charm spectroscopy, determinations of V_{us} and m_s from hadronic τ decays, Analytic approaches to non-perturbative QCD (WG4) focused on D decays and resonance lagrangians, Lattice methods (WG5) focused on weak matrix elements using Neuberger quarks and the impact on B-physics, K-physics and chiral perturbation theory and finally, Radiative return and Monte Carlo tools (WG6) discussed on MC generators for low energy hadronic cross section.
Plenary talks at *Euro-Flavour06*:

Speaker	*talk title*
Chris Sachrajda	*Lattice Computations in Kaon Physics*
M. Antonelli	*A working group on precise SM tests in K decays*
G. Isidori	*Minimal Flavour Violation: from quarks to leptons*
S. Trine	*Effects of New Physics on the rare decays $K_L \to \pi\ell^+\ell^-$*
M Davier	*Physics with e+e- and tau spectral functions*
G. Rodrigo	*PHOKHARA and the radiative return*
C. Smith	*Pion vector form-factor and the muon g-2*
F. Palombi	*Non-perturbative renormalization of four-fermion operators in the static approximation*
J. Heitger	*Towards a determination of the B_s-meson decay constant in two-flavour QCD*
S. Necco	*Chiral condensate from quenched lattice QCD*
T. Vladikas	*Lattice phenomenology from twisted mass QCD: a European approach to dynamical fermions*
A. Rusetsky	*The Delta resonance in a finite volume*
C. Farrel	*The top Yukawa Coupling at 500 GeV*
C. Reisser	*Top decay and electroweak effects at the $\bar{t}$–t threshold*
T. Nakada	*Experimental review on future B-physics*
S. Descotes-Genon	*QCD factorisation and flavour symmetries illustrated in $B_{d,s} \to KK$ decays*
T. Hurth	*Light-cone sum rules in soft-collinear effective theory*

M. Blanke/A. Buras	*FCNC Processes in the Littlest Higgs Model with T-Parity*
U. Nierste	*$B_s - B_s$ bar mixing in the Standard Model and beyond*
J. Charles	*Bayesian magic in flavour physics*
E. Passemar	*Scalar K pi form factor and new tests of the Standard Model*
C. Haefeli	*Aspects of ChPT at large m_s*
M. Misiak	*Weak radiative B-meson decay in the SM and beyond: the NNLO case*
J. Rohrer	*Phenomenology of $B \to VV$ decays*
F. De Fazio	*Rare B decays and Universal Extra Dimensions*
J. Soto	*$\Upsilon(nS) \to X\gamma$*
R. Kaiser	*Towards a consistent estimate of the chiral low-energy constants*
K. Kampf	*Role of vector resonances in the flavour symmetry breaking sector*
J. Bijnens	*Photons and partial quenching; $\eta \to 3\pi$ at two loops: Status report and preliminary results*

In addition their were plenary talks reporting from the working group sessions.

3.2 Euro-Flavour 07

The conference *Euro-Flavour07* took place at the Univ. Paris-Sud 11 in Orsay from 14-16 Nov 2007. The local organisers were D. Bećirević, S. Descotes-Genon, B. Moussallam, M.H. Schune and A. Stocchi (node 8). The format of this three-day conference was rather similar to that of the 2006 conference. There were 111 participants (among which a third of students, for which a special reduced fee was proposed) and 37 plenary talks, which were :

Speaker	*talk title*
B. Ananthanarayan	*Puzzles of excited charmed meson masses*
P. Beltrame	*New measurements of $\sigma(e^+e^- \to \pi^+\pi^-\gamma)$ cross section*
J. Bijnens	*$\eta \to 3\pi$ at two loops in ChPT*
H. Czyz	*Recent developments in the PHOKHARA generator*
B. Duling	*Lepton flavour violation in the littlest Higgs model with T-parity*
A. Fuhrer	*Cusp effects in $K \to 3\pi$ decays*
B. Haas	*On D-decays on the lattice*
C. Haefeli	*Integrating out strange quarks in ChPT*
J. Heitger	*Quark mass dependence of the heavy-strange meson decay constant in quenched QCD*
A. Hoang	*QCD factorisation for top mass reconstruction*
T. Hurth	*Rare decays with focus on electromagnetic corrections on $B \to X_s l^+ l^-$*
M. Jamin	*α_s and the tau hadronic width*

J. Kamenik	*Lattice chiral extrapolations in processes of positive and negative parity heavy mesons*
K. Kampf	*π^0 decays*
M. Kolesar	*Aspects of resummed ChPT*
E. Kou	*Anomalous enhancement of a penguin hadronic matrix element in $B \to K\eta'$*
L. Lellouch	*Light pseudoscalar mesons in 2+1 flavor QCD*
V. Lubicz	*Light-quark masses and pseudoscalar decay constants from $N_f = 2$ lattice QCD with twisted mass fermions*
J. Matias	*The Transverse Asymmetry A_T^2 of $B_0 \to K^{*0}(\to K\pi)\ell^+\ell^-$ in SM and supersymmetry*
B. Moussallam	*Light two-particle matrix elements of the $S = 1$ vector current*
M. Oertel	*Testing non-standard couplings to Z*
N. Offen	*V_{ub} and $B \to \pi$ form factors from light-cone sum rules revisited*
E. Passemar	*Matching two-loop ChPT with the dispersive representation of the $K\pi$ scalar form factor*
M. Pennington	*Can experiment distinguish between a molecule and an underlying quark state ?*
S. Peris	*What is resonance saturation ?*
A. Pineda	*$1/N_c$ and $1/n$ preasymptotic effects in current-current correlators*
H. Sazdjian	*Integral equation for gauge invariant quark Green's function*
O. Schneider	*LHCb*
F. Schwab	*Flavour physics and CP violation in the minimal 331 model*
I. Scimemi	*The jet mass of the top quark : two-loop properties*
P. de Simone	*Precision tests from kaon decays*
C. Smith	*Minimal flavour violation, seesaw and R-parity*
A. Stocchi	*Super flavour factories*
D. Straub	*$SO(10)$ SUSY GUTs with family symmetries: the test of FCNC*
S. Trine	*The Higgs sector of the MSSM and B-$\bar{B}$ mixing for large $\tan\beta$*
L. Vernazza	*Hadronic B decays on the MSSM at with large $\tan\beta$*
J. Virto	*Measuring ϕ_s with $B \to VV$ decays*

A special session was devoted to two main experiments which will play a major role in flavour physics in the next years. O. Schneider (CERN) gave an overview of the processes to be studied at LHCb, whereas A. Stocchi (LAL Orsay) provided an introduction to the two projects of Super Flavour Factory currently under discussion. An open discussion was organised so that the participants of the conference could improve their knowledge of these two major experimental projects in the field.

Time was also provided for the working groups. A special satellite meeting was organised for WG5 (Lattice) on Tuesday afternoon at LPT Orsay, before the opening of the conference. It was devoted to the determination of chiral low-energy constants from lattice QCD and to the

averaging procedure of results from different lattice groups. In addition, during the conference, on Wednesday afternoon, parallel sessions were organised for the six working groups. WG1 discussed experimental and theoretical issues on K_{l2} and K_{l3} decays. WG2 focused on inclusive and exclusive semileptonic $b \to c$ transitions. WG3 addressed issues in the theoretical description of quarkona and on the use of resonances for hadronic τ decays. WG4 investigated the interplay of large-N_c models of resonances with the determination of low-energy constants. WG5 discussed the use of effective theories (ChPT and HQET) on the lattice, and kept on discussing the issues raised in the Tuesday satellite meeting. WG6 studied issues realted to the PHOKARA Monte-Carlo generator. The outcome of these discussions was presented by the WG leaders on Friday afternoon in a dedicated plenary session.
In addition, during the time of the conference, an outreach conference was proposed in French by P. Roudeau (LAL Orsay) for the researchers and students of the campus of Orsay, but also for the inhabitants of the neighbouring towns. This colloquium on the history and the present of particle physics was organised in the framework of the local committee of the French Physical Society (SFP). This successful conference prompted the organisation of a second colloquium two months later in the same framework, more focused on the LHC Physics, by M. Giovannozzi (CERN).

3.3 Euro-Flavour 08

The conference *Euro-Flavour08* took place at the Institute for Particle Physics Phenomenology of Durham University from 22nd to 26th September 2008 with Michael Pennington and Linda Wilkinson as the local organisers. One day of the 4.5 days was devoted to the Midterm Review. There were 64 participants. All (but one) of the young researchers funded by Flavianet attended. The annual conference involved 38 talks. One of these by S. Descotes-Genon was a reminiscence of Jan Stern, a founder member of our European collaboration, who sadly died a few months ago. The talks are are set out in the table.

Speaker	*Talk title*
W. Altsmannshofer	*Low energy probes of CP violation in a flavour blind MSSM*
E. Ben-Haim	*Review of B-physics experiment*
F. Bernardoni	*ChPT in the mixed regime*
A. Bharucha	*Asymmetries in the decay mode $B \to K^* \mu^+ \mu^-$*
S. Bifani	*Chiral Perturbation Theory tests at the NA48/2 experiment*
D. Boito	*$K\pi$ vector form factor, dispersive constraints and $\tau \to \nu K \pi$ decays*
R. Boughezal	*Towards a complete NNLO prediction for $B \to s\gamma$ decay rate*
O. Cata	*α_s from tau decays: evidence for duality violations?*
A. Ceccucci	*Plans for NA62 experiment*

A. Crivellin	*New Constraints on the squark-mass-matrices of the MSSM*
G. Colangelo	*Review of lattice Methods and results II*
P. Colangelo	*Review of quarkonium physics*
H. Czyz	*Review of Monte Carlo tools*
G. D'Ambrosio	*Review of kaon physics*
S. Descotes-Genon	*Memories of Jan Stern*
M. Donnellan	*Moments of light-Cone distribution amplitudes from lattice QCD*
R. Escribano	*Derivation of the η' gluonic content from the J/ψ and ϕ meson decays*
C. Farrell	*Top pair associated Higgs production at the ILC*
P. Fritzsch	*Non-perturbative tests of HQET in two-flavour QCD*
M. Gorbahn	*Rare kaon decays*
J. Ilic	*Hadronic charmless threebody B decays at BaBar*
S. Ivashyn	*Momentum dependence of $a_0(980)$ and $f_0(980)$ meson interactions* *in RChT face the KLOE data*
I. Jemos	*Determination of low energy constants and testing ChPT at NNLO*
A. Jüttner	*Review of lattice methods and results I*
J. Kamenik	*Review of B-physics theory*
K. Kampf	*Decay $\pi^0 \to \gamma\gamma$ in ChPT*
L. Lellouch	*The light hadron spectrum in QCD*
P. Masjuan	*A rational approach to resonance saturation*
V. Mateu	*Heavy quark vaccuum polarization function at $O(\alpha_s^2)$ and $O(\alpha_s^3)$*
H. Neufeld	*Electromagnetic effects in $K_{\ell 3}$ decays*
S. Nicotri	*Studies in holographic QCD*
E. Passemar	*Robustness of the dispersive representation of $K_{\ell 3}$ form factors and analysis of KTEV data*
A. Pich	*Review of tau-physics*
G. Rodrigo	*A duality relation between loops and trees*
I. Rosell	*Resonance saturation at NLO*
J.J. Sanz-Cillero	*Some uses of Pade approximants: the vector form factor*

S. Wiesenfeldt	*Large quark mixing in* $SO(10)$
M. Zdrahal	*Dispersive approach to the cusp in* $K \to 3\pi$

The detailed schedule can be found at http://www.ippp.dur.ac.uk/Workshops/08/euroflavour08. We devoted a session to each of the Working Groups: Kaon physics, B-physics, tau-charm physics, Lattice methods and results, Monte Carlo methods and tools, and Analytic approaches to QCD. Each session began with a review of progress in the field, and where appropriate the interplay of theory and experiment, as well as presenting open issues.
The Mid-term Review consisted of an overview of the Network and its management by A. Pich, its training and networking by N. Brambilla, of recruitment by M.R. Pennington and a presentation on the research reporting mechanism by U. Nierste. All the participating Experienced Researchers and Early Stage Researchers funded by Flavianet gave individual presentations about their scientific and cultural experience, and the coordinator of each of the 11 Nodes of the Network reviewed progress over the past two years. The EU was represented by their consultant Prof. Fabrizio Fontana.

3.4 Euro-Flavour 09

The conference *Euro-Flavour09* took place in Bari, Italy. There were 58 participants, giving 41 talks in total. The talks are listed in the table below.

Speaker	*Talk title*
Johan Bijnens	*Kaon physics: recent results*
Simone Bifani	*Recent Results from the NA48/NA62 Experiments*
Ilaria Jemos	*Fitting Low Energy Constants at Next to Next to Leading order in Chiral Perturbation Theory*
Pere Masjuan	*Chiral Dynamics Predictions for* $\eta' \to \eta\pi\pi$
Emilie Passemar	*A new dispersive analysis of* $\eta \to 3\pi$
Karol Kampf	$\eta \to 3\pi$ *in the dispersive approach*
Marian Kolesar	$\eta \to 3\pi$ *in Resummed CHPT - methods and first preliminary results*
Michele Della Morte	*Heavy flavors on the lattice. Challenges and (some) new results*
Gilberto Colangelo	*Status report of the FLAG activities*
Gregory Vulvert	*Light hadron spectrum from lattice QCD*
Alberto Ramos	*The ratio* $\frac{f_K}{f_\pi}$ *in QCD*
Zhi-Hui Guo	*The extrapolation of the pion and kaon decay constants from resonance chiral theory to the lattice analysis*

Javier Virto	*B physics - theory review*
Concezio Bozzi	*B physics : experimental status and perspectives*
Sebastien Descotes-Jenon	*The two-Higgs doublet model of type II facing flavour physics data*
Sven Faller	$B_d \to J/\psi K_s$ *and* $B_s \to J/\psi\phi$
Laurent Lellouch	*Model independent description of* $B \to \pi\ell\nu$ *decays*
Dominik Scherer	$\tan(\beta)$ *enhanced SUSY corrections beyond the decoupling limit*
Lars Hofer	*Gluino mediated FCNCs in the MSSM with large* $\tan(\beta)$
Yu-Ming Wang	$\Lambda_b \to p\pi, pK$ *decays in* k_T *factorization*
Henryk Czyz	*Review of MC Methods and Radiative Return*
Antonio Pich	*Flavour constraints on multi-Higgs models*
Stefan Recksiegel	*Flavour Physics in the Littlest Higgs Model with T-Parity: Effects in the K, B and D systems*
Barbara Sciascia	*Status report from the Kaon Working Group*
Juan Jose Sanz Cillero	*Renormalization schemes in the SS-PP correlator at NLO in* $\frac{1}{N_c}$
David Wilson	*Schwinger-Dyson equations of the gauge sector of QCD*
Stefano Nicotri	*Finite temperature behaviour of scalar hadrons from a holographic description*
Antimo Palano	*New states in the open charm sector*
Nora Brambilla	*Review of quarkonium*
Simone Stracka	*Experimental results on quarkonium*
Diogo Boito	$K\pi$ *form factors and final state interactions in* $D^+ \to K^-\pi^+\pi^+$ *decays*
Pablo Roig	*Hadronic decays of the* τ *lepton into* 3π *and* $KK\pi$ *modes*
Maximilian Stahlhofen	*The QCD Static Potential in 2+1 Dimensions*
Floriana Giannuzzi	*Heavy hadron spectrum by an AdS/QCD potential*
Jennifer Girrbach	*Lepton Flavour Violation in the MSSM at large* $\tan(\beta)$
Katia Fratini	*First results from the MEG experiment*
Andreas Crivellin	*A-terms and a right-handed W coupling*
Maria Valentina Carlucci	B_s *physics in the Standard Model and in a scenario with a single Universal Extra Dimension*
Martin Gonzalez-Alonso	*New Physics bounds from CKM-unitarity*

Matthaeus Bartsch	*CP Violation in $B \to V_L V_L$*
Wei Wang	*Probing the structure of light scalar mesons from B meson decays*

The detailed schedule can be found at http://www.ba.infn.it/euroflavour2009. We devoted a session to each of the Working Groups: Kaon physics, B-physics, tau-charm physics, Lattice methods and results, Monte Carlo methods and tools, and Analytic approaches to QCD. Each session began with a review of progress in the field, and where appropriate the interplay of theory and experiment, as well as presenting open issues.

3.5 Euro-Flavour 10

The conference *Euro-Flavour10* took place in Munich, Germany. There were 101 participants, giving 58 talks in total. The talks are listed in the table below.

Speaker	*Talk title*
Andrzej Buras	*Introduction to flavour physics*
Gilberto Colangelo	*Results from Flavianet: FLAG*
Wolfgang Altmannshofer	*B physics review theory*
Andreas Crivellin	*B physics review theory*
Thomas Kuhr	*Recent Experimental B Physics Results*
Rainer Sommer	*Perturbative and non-perturbative uncertainties in HQET-QCD matching*
Joachim Brod	*Rare K Decays and $\epsilon(K)$: Theory Prediction*
Bastian Kubis	*Rescattering effects in $\eta \to 3\pi$ decays*
Gino Isidori	*Precise tests of the Standard Model with data on leptonic and semileptonic kaon decays (Review talk WG Kaon)*
Nils Offen	*On renormalization of heavy-light light ray operators*
Carina Popovici	*Coulomb gauge confinement in the heavy quark limit*
Stefania Gori	*Higgs mediated flavour changing neutral currents*

Christoph Promberger	*Flavour Violation in the Presence of a Fourth Generation*
Ilaria Jemos	*Hard Pion Chiral Perturbation Theory for $B \to \pi$ and $D \to \pi$ form factors*
Andrey Tayduganov	*Determining the photon polarization of the radiative $B \to K_1(1270)$ gamma decay*
Andre Hoang	*Charm quark mass from relativistic sum rules*
Giulia Ricciardi	*Resummed Massive spectra in Heavy quark decays*
Joaquim Matias	*New Physics reach of the decay mode $B \to K^* l^+ l^-$*
Bachir Moussallam	*MO analysis of new Belle results on photon-photon scattering with chiral constraints*
Guillaume Toucas	*Lattice hints of a strong dependence of pseudoscalar observables on the strange quark mass*
Marian Kolesar	*$\eta \to 3\pi$ in Resummed CHPT*
Ignasi Rosell	*The Vector Form Factor within Resonance Chiral Theory: estimation of L_9*
Bertrand Echenard	*WG3 tau/charm $\&$ quarkonium review: Exploring the world of heavy quarkonium*
Yukinari Sumino	*QCD potential at three-loop order*
Pablo Roig-Garces	*Precise determination of the η_c mass and width in radiative J/Ψ decays*
Svjetlana Fajfer	*Light colored scalars and the low energy phenomenology*
Pedro Ruiz-Femenia	*Electroweak non-resonant corrections to top-pair production close to threshold*
Vicent Mateu	*Thrust at N^3LL with Power Corrections and a Precision Global Fit for α_s*

Jacopo Ghiglieri	*Heavy quarkonium spectrum and width in a weakly-coupled quark-gluon plasma*
Maximilian Stahlhofen	*The QCD static potential in 2+1 dimensions*
Diogo Boito	*$K\pi$ vector form factor constrained by τ and K_{l3} decays*
Benoit Blossier	*Quark masses from $N_f = 2$ simulations*
Michael Donnellan	*The $B^*B\pi$ coupling*
Antonin Portelli	*Electromagnetic corrections to light hadron masses in lattice QCD+QED*
Jie Lu	*QCD-like Theories at Next-to-Next-to-Leading order*
David Palao	*Non-perturbative computation of renormalization constants of bilinears operators with 4 dynamical flavours*
Alberto Ramos	*The octect baryon sigma term*
Henryk Czyz	*Review of WG Radiative return and Monte Carlo tools*
Floriana Giannuzzi	*Production-decay interferences in s-channel single-top produ ction at NLO QCD*
Johan Bijnens	*Status of the new L_i^r fit at order p^6*
Paula Tuzon	*Low energy constraints on the aligned two-Higgs-doublet model*
Lisa Carloni	*Leading Logarithms and Renormalization of massive $O(N)$*
Juan Jose Sanz-Cillero	*Scalar and Pseudo-scalar correlators in $1/N_c$*
Zhi-Hui Guo	*Phenomenology study from U(3) chiral perturbation theory*
Karol Kampf	*Light-meson decays*
Stefan Lanz	*A new dispersive analysis of $\eta \to 3\pi$*
Gino Isidori	*Quark flavour mixing with right-handed currents: an eff ective theory approach*

Jacobo Ruiz de Elvira	*Structure of the lightest scalar meson from the $1/N_c$ expansion of unitarized Chiral Perturbation Theory and Regge behavior*
Pere Masjuan	*Analytical Approximations for the extrapolation of lattice data*
David Greynat	*Resummation of Threshold, Low- and High-Energy Expansions*
Stefano Nicotri	*Properties of heavy quarks at finite temperature and density in a holographic approach*
Samuel Friot	*Analytic continuation of integrals of the "Feynman diagrams"-type from multidimensional Mellin-Barnes representation*
Oscar Cata'	*Holography and the muon (g-2)*
Laurent Lellouch	*Nonperturbative 2+1 flavor QCD at the physical point: determining the light quark masses*
Christopher Sachrajda	*Prospects for Lattice Calculations of Nonleptonic Kaon Decays*
Andreas Weiler	*Flavour Physics beyond the SM*
Cristoforo Simonetto	*Review of Lepton Flavor Violation*
Chris Quigg	*Future Approaches to Flavour Physics*

Furthermore, the following ESR and ER members of the network have participated in the conference: Emilie Passemar, Nils Offen, David Greynat, Ilaria Jemos, Martin Zdrahal, Vicent Mateu, Francesco Virotta, Michael Donnellan, Maximilian Stahlhofen, Patrick Fritzsch, Alberto Ramos, Zhi-Hui Guo, Stefano Nicotri, Pablo Roig, David Palao, Pere Masjuan, Floriana Giannuzzi, Jacobo Ruiz de Elvira, and Carina Popovici.

The detailed schedule can be found at http://euroflavour2010.ph.tum.de. We devoted a session to each of the Working Groups: Kaon physics, B-physics, tau-charm physics, Lattice methods and results, Monte Carlo methods and tools, and Analytic approaches to QCD. Each session began with a review of progress in the field, and where appropriate the interplay of theory and experiment, as well as presenting open issues.

3.6 Conferences and workshops within FLAVIA*net*

Several conferences and workshops took place in the FLAVIA*net* nodes. Here we list both genuine FLAVIA*net* meetings and international conferences and workshops organised by FLAVIA*net* members at their home institutions.

Node no.	Conference/Workshop
3	*LHCb upgrade workshop*, Univ. of Durham, UK, 11-12 January 2007
3	*ApeNEXT: Computational Challenges and First Physics Results*, Galileo Galilei Institute for Theoretical Physics, Arcetri, Italy, 8-10 February 2007.
5	FLAVIAnet *Mini-Workshop on Kaon Decays*, Laboratori Nazionali di Frascati, Frascati, Italy, 18-19 May 2007.
5	*Kaon 2007*, May 21-25 2007, Frascati National Laboratories of INFN, Italy. http://www.lnf.infn.it/conference/kaon07/
1	*V. European Twisted Mass Collaboration Meeting*, 11-12 June 2007, Valencia
5,8	*Lattice computations and subatomic physics*, 14-15 June 2007, Orsay
3	*Heavy Flavour Physics (UK Forum)*, Univ. of Durham, UK, 21-22 June 2007
7	*4th International Pion-Nucleon PWA Workshop* 26-29 Jun 2007, Helsinki, Finland, http://www.hip.fi/∼pwa07/
4	*15th International Conference On Supersymmetry And The Unification Of Fundamental Interactions (SUSY07)*, 26 Jul - 1 Aug 2007, Karlsruhe, Germany, http://www.susy07.uni-karlsruhe.de
5	*QCD in extreme conditions*, 6th - 8th August 2007, Frascati National Laboratories of INFN, Italy, http://www.lnf.infn.it/conference/xqcd2007/
3	*Renormalization Group and EFT*, Univ. of Durham, UK, 27-29 September 2007
1	*SuperB Workshop VI: New Physics at the Super Flavour Factory SuperB*, 7th - 15th January 2008, Valencia (Spain) http://ific.uv.es/superb
1	*10th International Workshop on Neutrino Factories, Super beams and Beta beams*, 30th June - 5th July 2008, Valencia (Spain) http://ific.uv.es/nufact08
2	*HADRONTH07: Workshop of the HADRONTH network of the HADRONPHYSICS I3 EU project*, 1st - 4th October 2007, Barcelona, Spain, http://www.ecm.ub.es/ bruno/hadron07/
2	*School on Flavor Physics*, 13th - 25th July 2008, Benasque, Spain, http://benasque.ecm.ub.es/2008flavor/2008flavor.htm
5	*Flavianet Kaon Workshop* 12th - 14th June 2008, Anacapri (Italy) http://flavianetcapri.na.infn.it

5	*Second Workshop on Theory, Phenomenology and Experiments in Heavy Flavour Physics* 16th - 18th June 2008, Anacapri (Italy) http://web.na.infn.it/index.php?id=b-physics-capri
5	*V Italian Informal Meeting on B Physics* 3rd-4th April 2008, Cagliari (Italy) http://www.ca.infn.it/ gruppo1/IncontriB_08/index.html
5	*International Workshop on e^+e^- collisions from Φ to Ψ* 7th-10th April 2008, Frascati (Italy) http://www.lnf.infn.it/conference/phipsi08/
5	*XIII LNF Spring School in Nuclear, Subnuclear and Astroparticle Physics* 12th -16th May 2008 Frascati (Italy) http://www.lnf.infn.it/conference/lnfss/08/
6	*International Linear Collider ECFA Workshop*, 9-12 June 2008, Warsaw, Poland http://ecfa2008.fuw.edu.pl/
8	*Lattice Simulations of Quantum Fields*, 26th March - 1st April 2008, LPT Orsay, http://www.th.u-psud.fr/block-course/
11	*Sixth International Workshop on Chiral Dynamics (Theory and Experiment)*, 6th-10th July 2009, Berne, Switzerland, http://www.chiral09.unibe.ch
11	*Hadron Physics Summer School*, 11th - 15th August, Bad Honnef, Germany, http://www.fz-juelich.de/ikp/hpss2008
11	*MENU2007 – 11th International Conference on Meson-Nucleon Physics and the Structure of the Nucleon*, 10-14 September 2007, Jülich, Germany, http://www.fz-juelich.de/ikp/menu2007
11	*39. Arbeitstreffen Kernphysik*, 21-28 February 2008, Schleching, Germany, http://www-win.gsi.de/AK-Schleching2008
11	*QCD, spin physics and chiral dynamics in nuclei Session, International Conference on Particles And Nuclei (PANIC08)*, November 2008, Eilat, Israel, http://www.weizmann.ac.il/conferences/panic08
11	*NSTAR 2007 – Workshop on the Physics of Excited Nucleons*, 5-8 September 2007, Bonn, Germany, http://nstar2007.uni-bonn.de
11	*LIGHT CONE 2008 – Relativistic Nuclear and Particle Physics*, 7-11 July 2008, Mulhouse, France http://clrwww.in2p3.fr/LC2008
11	*Vth International Conference on Quarks and Nuclear Physics (QNP08/09)*, 2008/2009, Beijing, China, http://tpcsf.ihep.ac.cn/QNP09/index.htm
11	*Perspectives and challenges for full QCD lattice calculations*, 5th - 9th May 2008, Trento, Italy, http://www.ect.it
1	*PROMETEO I: LHC physics and cosmology*, 2nd - 6th March 2009, Valencia (Spain) http://ific.uv.es/ gabriela/miniworkshop.html
1	*International Workshop on Effective Field Theories*, 2nd - 6th February 2009, Valencia (Spain) http://ific.uv.es/eft09

3	*Annual UK Particle Theory Meeting*, 18-20 December 2008, Durham (UK) http://www.ippp.dur.ac.uk/Xmas/08/
3	*Higgs-Maxwell Meeting*, 4 February 2009, Edinburgh (UK) http://www.ippp.dur.ac.uk/Workshops/09/HMW/
3	*London Workshop on Standard Model discoveries with early LHC data*, 30 March-1 April 2009, London (UK) http://www.hep.ucl.ac.uk/smlhc/Site/
3	*Workshop on New Physics with SuperB*, 14-17 April 2009, Warwick (UK) http://www2.warwick.ac.uk/fac/sci/physics/research/epp/meetings/superb2009
3	*Flavour physics in the era of precision neutrino experiments*, 9-11 June 2009, Abingdon (UK) http://www.ippp.dur.ac.uk/Workshops/09/Coseners
4	*Ringberg Workshop on New Physics, Flavors and Jets*, April 27 - May 1, 2009, Ringberg Castle, Rottach-Egern (Germany) http://indico.mppmu.mpg.de/indico/conferenceDisplay.py?confId=433
4	*Potential and Prospects for Super Flavour Factories*, 31st October - 1st Novemver 2008, Munich (Germany) http://indico.mppmu.mpg.de/indico/conferenceDisplay.py?confId=341
4	*Progress and Challenges in Flavour Physics*, 29th September -31rd October 2009, Primosten (Croatia) http://hippo.irb.hr/primosten09/
5	*LNF Spring School*, 11th - 15th January 2008, Frascati (Italy) http://www.lnf.infn.it/lnfss09
5	*Rencontres de Physique de la Vallée d'Aoste*, 3th - 10th March 2009, La Thuile (Italy) http://www.pi.infn.it/lathuile
5	*Summer School on Particle Physics in the LHC ERA*, June 2009, ICTP, Trieste (Italy) http://users.ictp.it/ ktsumura/WebPage/
6	*FLAVIANET TOPICAL WORKSHOP: Low energy constraints on extensions of the Standard Model*, 23-27 July 2009 Kazimierz (Poland) http://czyz.phys.us.edu.pl
6	*XXIII International Conference of Theoretical Physics MATTER TO THE DEEPEST: Recent Developments in Physics of Fundamental Interactions*, 11th-16th September 2009 Ustroń (Poland) http://prac.us.edu.pl/ us2009
6	*The 2009 Europhysics Conference on High Energy Physics*, 16-22 July 2009 Kraków (Poland) http://www.ifj.edu.pl/hep2009/
8	*SuperB Workshop VIII: New Physics at the Super Flavour Factory SuperB*, 15th - 18th February 2009, Orsay (France) http://events.lal.in2p3.fr/conferences/SuperB09/
9	*Chiral Dynamics 2009*, 6th - 10th July 2009, Bern (Switzerland) http://www.chiral09.unibe.ch

9	*Joint Physics Meetings of the LHCb Collaboration and the Theory Group* 28.11.2008, 27.01.2009, and 29.05.2009, Cern, Geneva (Switzerland)
9	*Working group on the interplay of collider and flavour physics* 16.-18.12.2009, Cern, Geneva (Switzerland)
10	*5th Vienna Central European Seminar on Particle Physics and Quantum Field Theory: Highlights in Computational Quantum Field Theory*, 28th - 30th November 2009, Vienna (Austria) http://www.univie.ac.at/vienna.seminar/2008/
11	*Modern perspectives in lattice QCD*, summer school, 3-28 Aug 2009, Les Houches (France) http://julian.tau.ac.il/Houches2009/Houches0809.html
11	*LATTICE PRACTICES 2008*, summer school, 8-10 Oct 2008, Zeuthen (Germany), https://indico.desy.de/conferenceDisplay.py?confId=1113
11	*"Frontiers in Nuclear Physics," Symposium in honor of Walter Glöckle's 70th birthday*, June 18-20, 2009, Bad Honnef (Germany) http://www.pbh.de
11	*"Charmed Exotics" (447-th Wilhelm and Else Heraeus Seminar)*, Aug. 10-12, 2009, Bad Honnef (Germany) http://www.pbh.de
11	*"Hadron Structure and Dynamics"*, Aug. 13-14, 2009, Bad Honnef (Germany) http://www.pbh.de
11	*19th International IUPAP Conference on Few-Body Problems in Physics "FB 19"*, Aug. 31 - Sept. 5, 2009, Bonn (Germany) http://fb19.hiskp.uni-bonn.de
11	*International Advisory Committee of the conference "Vth International Conference on Quarks and Nuclear Physics (QNP08/09)"*, 2008/2009, Beijing (China) http://tpcsf.ihep.ac.cn/QNP09/index.htm
11	*International Workshop "Chiral Dynamics VI: Theory and Experiment"*, July 6-10, 2009, Bern (Switzerland) http://www.chiral09.unibe.ch
11	*PrimeNet Workshop*, 8th - 9th October, Bonn, Germany, http://www.itkp.uni-bonn.de/ kubis/PrimeNet/Program.html
1,2	*Chiral10 WORKSHOP*, June 21-24, 2010. Valencia, Spain. http://ific.uv.es/nucth/chiral10/
3	FLAVIAnet meeting, Southampton, UK, 14-15 December 2009. *Flavour physics with the Relativistic Heavy Quark action* http://www.hep.phys.soton.ac.uk/ctslx
3	*Annual UK Particle Theory Meeting*, 17-19 December 2009, Durham (UK) http://www.ippp.dur.ac.uk/Xmas/09/

3	*Higgs-Maxwell Meeting*, 10 February 2010, Edinburgh (UK) http://www.ippp.dur.ac.uk/Workshops/10/HMW/
3	Workshop on Theory Experiment interplay at LHC, London, 8-9 April 2010 http://www.ippp.dur.ac.uk/Workshops/10/Th-Exp-LHC/
3	BOOST 2010, Oxford, 22-25 June 2010 http://www.physics.ox.ac.uk/boost2010/
3	Tools 2010, *Tools for SUSY and the new physics*, Winchester, 29 June-2 July, 2010 http://www.next-institute.ac.uk/TOOLS2010
3	CKM2010: 6th International Workshop on the CKM Unitarity Triangle, Warwick, 6-10 September 2010 http://www2.warwick.ac.uk/fac/sci/physics/research/epp/meetings/ckm2010
3	*L*attice meets Phenomenology, Durham 15-17 September 2010 http://www.ippp.dur.ac.uk/Workshops/10/latticephenomenology
3	*i*NEXT: the NEXT phase of particle physics, Brighton, 23-24 September 2010 http://pact.phys.susx.ac.uk/inext/
4	*Out-of-Equilibrium Quantum Fields in the Early Universe*, 6-8 Sep 2010, Aachen (Germany) http://tpe.physik.rwth-aachen.de/workshops/noneq/Main.html
5	*Rencontres de Physique de la Vallée d'Aoste*, 28th Feb. – 6th March 2010, La Thuile (Italy), http://www.pi.infn.it/lathuile
5	*Third Workshop on Theory, Phenomenology and Experiments in Heavy Flavour Physics*, 5h Feb. – 7th July 2010, Capri (Italy), http://web.infn.it/caprifp2010/
5	*Indirect Searches for New Physics at the time of LHC*, 15h Feb. – 26th March 2010, GGI, Florence (Italy), http://www.ggi.fi.infn.it/
8	*Colloquium in memory of Jan Stern*, 2-3 October 2009, Paris (France) http://confjstern.in2p3.fr/
8	*ICHEP 2010: International Conference on High-Energy Physics*, 22-28 July 2010, Paris (France) http://www.ichep2010.fr/
9	*Working group on the interplay of collider and flavour physics* 14-16 Dec 2009, CERN (Switzerland)
9	"The New, the Rare and the Beautiful", Workshop at University of Zurich 7-9 Jan 2010, Zurich, Switzerland
9,11	*Future directions in lattice gauge theory 2010*, 19 Jul - 13 Aug 2010, CERN (Switzerland) http://phdepth.web.cern.ch/phdepth/content2/THInstitutes/2010/LGT1
10	*6th Vienna Central European Seminar on Particle Physics and Quantum Field Theory: Effective Field Theories*, 27th - 29th November 2009, Vienna (Austria) http://www.univie.ac.at/vienna.seminar/2009/index.html

3.7 Other conferences and workshops

FLAVIA*net* researcher have given roughly 1100 talks at conferences and workshops during the four years of the network. These talks are listed in the annual reports and this information is not repeated here.
We instead only list the conferences attended by researchers funded from the network and quote the titles of their talks:
Early stage researchers (ESR):

Name	Node no.	Conference/Workshop *talk title*	
Emilie Passemar	8	Kaon International Conference (KAON'07) 21-25 May 2007, Frascati, Italy, *Dispersive representation and shape of $K_{\ell 3}$ form factors*	ESR
Benjamin Haas	8	Lattice 07, XXV International Symposium on lattice field theory, 30 Jul - 4 Aug 2007, Regensburg, Germany, *Improving the extraction of semileptonic form factors from LQCD*	ESR
Vicent Mateu	4	SCET 2008 Workshop, 3-5 Apr 2008, Mainz, Germany,	ESR
Vicent Mateu	4	International Workshop on Effective Theories: From the Pion to the Upsilon, Valencia, February 2009. *A Global Fit for Thrust at NNNLL: Precision Determination of $\alpha_s(M_z)$*	ESR
Pablo Roig Garces	5	Int. Workshop on Effective Field Theories, Valencia, Spain, Feb 2009, *Hadronization in three meson channels at tau decays and e^+e^- cross-section*	ESR
		DPG 2009, Munich, Mar 2009, *A framework improving the hadronization of QCD currents*	ESR
Sergiy Ivashyn	6	International Workshop on Effective Field Theories: from the Pion to the Upsilon, 2-6 February 2009, Valencia, Spain. *On modeling the scalar meson dynamics with RChT*	ESR
		FLAVIANET TOPICAL WORKSHOP: Low energy constraints on extensions of the Standard Model, 23-27 July 2009 Kazimierz (Poland). *Testing models for final state photon emission in pi+pi- production at e+e- colliders*	ESR
		XXXIII International Conference of Theoretical Physics MATTER TO THE DEEPEST: Recent Developments in Physics of Fundamental Interactions, Ustroń, Poland September 11-16, 2009. *Radiative return: a progress on FSR tests*	ESR
Ilaria Jemos	7	EFT09: International workshop on effective field theories, Valencia, Spain, 2-6/2/2009. *Determination of Low Energy Constants and testing Chiral Perturbation Theory at Next to Next to Leading Order*	ESR

		Sixth International Workshop on Chiral Dynamics, Berne 6-10 July, 2009. *Relations at Order p^6 in Chiral Perturbation Theory*	ESR
N. Offen	8	International Workshop on Effective Field Theories: from the Pion to the Upsilon (EFT 09), Valencia, Spain. February 2009. *Renormalization of B-meson distribution amplitudes*	ESR
Simone Bifani	9	XVII International Conference on Supersymmetry and the Unification of Fundamental Interactions (SUSY09) - Boston (United States), 5th-10th June 2009, *Standard Model tests at the NA62 CERN experiment*	ESR
	9	New Opportunities in the Physics Landscape at CERN - Geneva (Switzerland), 10th - 13th May 2009	ESR
Emilie Passemar	9	5^{th} International Workshop on the CKM Unitarity Triangle, University of La Sapienza, Roma, Italy, September 9-13, 2008. *Dispersive approaches for Kl3 form factors*	ESR
	9	Euroflavour08, Annual Workshop of the European Flavour Physics Network FLAVIAnet, IPPP, Durham, UK, September 21-28, 2008. *Robustness of the dispersive representation of the $K_{\ell 3}$ form factors and analysis of KTeV data*	ESR
	9	French Particle Physics Meeting, Ecole Polytechnique, Palaiseau, France, March 23-25, 2009. *Dispersive representation of the $K_{\ell 3}$ form factors and applications*	ESR
	9	Kaon International Conference (KAON'09), Tsukuba, Japan, June 9-12 2009. *Precision SM calculations and theoretical interests beyond the SM in $K_{\ell 2}$ and $K_{\ell 3}$ decays*	ESR
Martin Zdrahal	10	International Workshop on Effective Field Theories: from the pion to the upsilon, Valencia, Spain, February 2009, *Dispersive construction of two-loop $P \to 3\pi$ ($P = K, \pi$) amplitudes*	ESR
		47. Internationale Universitätswochen für Theoretische Physik, Schladming, Austria, February 2009	ESR
		Workshop on Chiral Dynamics 2009, Bern, Switzerland, July 2009	ESR
Michael Donnellan	11	11th Meeting of the SFB/TR 9, RWTH Aachen, Aachen, October 2008	ESR
		Lattice Practices 2008, DESY Zeuthen, Zeuthen, October 2008	ESR
		12th Meeting of the SFB/TR 9, DESY Zeuthen, Zeuthen, March 2009	ESR
		Introduction to Jugene and Juropa Forschungszentrum Jülich, Jülich, August 2009	ESR

		4th VI-HPS Tuning Workshop, Universität Bremen, Bremen, September 2009	ESR
Francesco Virotta	11	Lattice Practices 2008, DESY Zeuthen, Zeuthen, October 2008.	ESR
		12th Meeting of the SFB/TR 9, DESY Zeuthen, Zeuthen, March 2009.	ESR
		Modern perspectives in lattice QCD: Quantum field theory and high performance computing, École de physique des Houches, Les Houches, France, August 2009.	ESR
David Palao	5	Lattice 2010, Villasimius (Italy), June 2010, *Renormalization constants for Wilson Fermions with four dynamical flavours*	ESR
Ilaria Jemos	7	Particle days 2009, 1-2 October 2009, Lund, Sweden. *Determination of Low Energy Constants and testing Chiral Perturbation Theory at Next to Next to Leading Order*	ESR
		6th Vienna Central European Seminar on Particle Physics and Quantum Field Theory 27-29/11/2009, Vienna, Austria.	ESR
P. Roig-Garcès	8	QCD10. Montpellier, France. June 2010 $\tau \to \eta\pi\pi\eta$ *and* $e^+e^- \to \eta\pi\pi$ *at low energies*	ESR
		Quark confinement and the hadron spectrum. Madrid, Spain. September 2010 J/ψ *Radiative transitions to* η_c	ESR
		Tau 10. Manchester, UK, September 2010 *Hadronization effects in* $\tau \to \pi\gamma\nu$ *decays*	ESR
Pere Masjuan	10	PrimeNet Workshop 2009, Bonn, Germany. October 2009 $\eta' \to \eta\pi\pi$ *in different chiral frameworks*	ESR
		6th Vienna Central European Seminar on Particle Physics and Quantum Field Theory: Effective Field Theories, Vienna, Austria. November 2009. *Chiral dynamics predictions for* $\eta' \to \eta\pi\pi$	
		QCD at Work: International Workshop on QCD - Theory and Experiment, Martina Franca, Italy. June 2010. *Analytic approximants for the extrapolation of lattice data*	
		QCD 2010, 15th International QCD Conference, Montpellier, France. June/July 2010. *Unfolding the second Riemann sheet with Padé approximants: hunting resonance poles*	
		Quark Confinement and the Hadron Spectrum, Madrid, Spain. August/September 2010. *Hunting resonance poles with Padé approximants: a model-independent method*	

Martin Zdrahal	10	PrimeNet Workshop 2010, Lisbon, Portugal. September 2010. *Final state interactions in* $\eta' \to \eta\pi\pi$ Colloquium in memory of Jan Stern, Paris, France. October 2009. Meeting in honour of Chris Sachrajda, Southampton, United Kingdom. December 2009. *Dispersive construction of the two-loop* $\eta \to 3\pi$ *amplitude*	ESR

Experienced researchers (ER):

Name	Node no.	Conference/Workshop *talk title*	
Christoph Haefeli	1	XIII IFT-UAM/CSIC Christmas Workshop, Madrid, Spain, (December 2007).	ER
Jernej Fesel Kamenik	5	Charm 2009, Leimen, Germany, May 2009, *Theory of semileptonic decays*	ER
		Europhysics Conference on High Energy Physics, Krakow, Poland, Jul 2009, *Signatures of Heavy Vectors in Higgsless models*	ER
		Low energy constraints on extensions of the Standard Model (Flavianet Topical Workshop), Kazimierz, Poland, Jul 2009 *Lepton Flavour Violation in Minimal See-saw Models*	ER
A. Ramos	8	XXVII International Symposium on Lattice Field Theory (Lattice 2009), Beijing. July 2009. F_K/F_π *in* $N_f = 2 + 1$ *QCD and a determination of* $\lvert V_{us}\rvert$	ER
Emilie Passemar	1	Colloquium in memory of J. Stern, Paris, France, October 2-3, 2009.	ER
		PrimeNet Workshop on eta-eta' physics, Bonn, Germany, October 8 - 9, 2009.	ER
		NA62 Physics Handbook Workshop, CERN, Geneva, Switzerland, December 10 - 12, 2009. *Dispersive approach to* $K_{\ell 3}$ *form factors*	ER
		35^{th} International Conference on High Energy Physics, Paris, France, July 22 - 28, 2010.	ER
		Quark Confinement and the Hadron Spectrum IX, Madrid, Spain, August 30 - September 3, 2010. *Constraints on the* $K\pi$ *form factors from* $\tau \to K\pi\nu_\tau$ *and* $K_{\ell 3}$ *decays*	ER
		The 11^th International Workshop on Tau Lepton Physics, Manchester, UK, September 13 - 17, 2010. *Constraints on the* $K\pi$ *form factors from* $\tau \to K\pi\nu_\tau$ *and* $K_{\ell 3}$ *decays*	ER
A. Ramos	8	Workshop in the honour of Chris Sachrajda. Southampton, UK. December 2009. *The ratio* F_K/F_π *in full QCD*	ER

		Lattice10. Villasimus, Italy. May 2010 *Sigma term and strange content of the nucleon*	ER
		QCD10. Montpellier, France. June 2010 *State-of-art lattice results of QCD with light flavours*	ER
		ICHEP10. Paris, France. July 2010 *Some phenomenology from the lattice: decay constants and sigma terms*	ER
		CKM10. Warwick, UK. September 2010 F_K/F_π *from the BMW collaboration*	ER

Note that the talks given by our ESR and ER at Euro-Flavour conferences are not included in the tables above, but are listed in Sect. 3.1–3.5. Their involvement in our annual Schools on Flavour Physics are documented in our Training Report.

3.8 General Networking

During the reporting period the FLAVIA*net* nodes have pursued an active scientific exchange. Here we list the visits focusing on research; visits devoted to training are listed in the Training Report.

Name	from Node no.	to Node no.	dates
Catalina Espinoza	1	3	17/7/2007 – 17/11/2007
Christoph Haefeli	1	9	18/12/2006 – 7/1/2007
	1	11	22/1/2007 – 24/1/2007
	1	9	2/4/2007 – 2/5/2007
Pilar Hernández	1	9	1/7/2007 – 15/8/2007
Silvia Necco	1	9	2/7/2007 – 28/07/2007
	1	9	19/11/2007 – 3/12/2006
	1	11	18/6/2007 – 22/06/2007
Antonio Pich	1	9	17/7/2007 – 27/7/2007
David Greynat	1	8 (IPN-Orsay)	24th March - 6th April 2008
David Greynat	1	8 (Marseille)	7-9th April 2008
Silvia Necco	1	9	25-26 March 2008
Silvia Necco	1	5	26th May 2008
Christoph Haefeli	1	9	1st January - 29th February 2008
Vicent Mateu	1	4 (MPI)	Sep 15 – Nov 30, 2008
E. Pallante	1	11	19 May 2008
Antonio Pich	1	5	7-10 April 2008
Antonio Pich	1	9	1st May - 31 July 2008
Matthias Jamin	2	4	13/6
Joaquim Matias	2	12	16/4
Joaquim Prades	2	1	15/1-20/1
	2	12	1/1-31/11

Rafel Escribano	2	5	27/3
	2	5	5/7
Lluis Garrido	2	5	15/3-16/3
	2	5	25/4-25/4
	2	5	5/6-8/6
	2	5	10/7-13/7
	2	5	23/7-27/7
Ricardo Graciani	2	5	27/2
	2	5	10/5 - 18/5
	2	5	25/6-28/6
	2	5	31/7-3/8
	2	5	13/8-16/8
Felix Schwab	2	4	5/4
Patricia Ball	3	4	1 April-30 Sept 2008
Aiofe Bharucha	3	4	8-15 June, 2008
C. Thomas	3	8	9/4/08 - 11/4/08
Roman Zwicky	3	4 (Aachen)	16–20 Jun 2008
Martin Beneke	4	11 (Bonn)	7/5
	4	11 (Mainz)	12/6
Monika Blanke	4	3 (Durham)	21/6 - 22/6
Cailin Farrell	4	3 (Durham)	12/2 - 17/2
Agnieszka Grzelinska	4	5 (Frascati)	23/6 - 7/7
	4	6 (Katowice)	11/4 - 18/4 and 3/9 - 14/9
	4	1 (Valencia)	27/3 - 3/4
Andre Hoang	4	1 (Valencia)	6/11 - 10/11
	4	9 (Zurich)	6/11 - 10/11
Thomas Mannel	4	5 (Frascati)	13/11 - 15/11
Ulrich Nierste	4	11 (Mainz)	15/11
Anton Poschenrieder	4	3 (Durham)	29/11 - 2/12
Christoph Reißer	4	3 (Durham)	10/10 - 14/10
Maximilian Stahlhofen	4	1 (Valencia)	6/11 - 10/11
Stéphanie Trine	4	5 (Frascati)	21/5 - 26/5
Johann Kühn	4	5 (Frascati)	7–10 Apr 2008
Ulrich Nierste	4	5 (Cagliari)	3–4 Apr 2008
André Hoang	4	5 (Florence)	Oct 1-5, 2007
André Hoang	4	10 (Vienna)	Oct 29, 2008
Maximilian Stahlhofen	4	8 (Orsay)	Nov 14-16, 2007
Cailin Farrell	4	8 (Orsay)	Nov 14-16, 2007
Christoph Reisser	4	3 (Durham)	Oct 10, 2007
Christoph Reisser	4	8 (Orsay)	Nov 14-16, 2007
N. Brambilla	5	1	April–August 2007
P. Colangelo	5	9	October 2007 (1 week)
F. De Fazio	5	3	February 2007 (1 week)

R. Frezzotti	5	11	August 2007 (1 week)
G. Isidori	5	12	March 2007 (1 week)
F. Jugeau	5	1	February 2007 (1 week)
G.C. Rossi	5	11	January 2007 (1 week)
G.C. Rossi	5	11	July–August 2007
L. Silvestrini	5	9	May 2007 (1 week)
L. Silvestrini	5	12	March 2007 (1 week)
A. Vairo	5	1	April–August 2007
P. Colangelo	5	8	7/10/07 - 18/10/7
	5	8	29/6/08 - 6/7/08
Fulvia De Fazio	5	4	November 2007 (1 week)
	5	8	February 2008 (1 week)
R. Frezzotti	5	11	12.7.-19.7.07
Marco Ciuchini	5	8	20-23/2/2008
Jernej Kamenik	5	8 (Orsay)	12–21 Dec 2008
	5	8 (Lubljana)	29/2 –10/3 2008
	5	4 (Karlsruhe)	4–7 Jun 2008
Javier Virto	5	2	10/4–20/4 2008
	5	2	16/6–23/6 2008
Vittorio Lubicz	5	8	31/3-3/4 2008
Gino Isidori	5	3	Jan 2008 (1 week)
	5	9	June 2008 (1 week)
Federico Mescia	5	8	April 2008 (1 week)
Enrico Nardi	5	8	June 2008 (1 week)
Henryk Czyż	6	5	11/10/06 - 26/10/06
	6	5	24/06/07 - 27/06/07
	6	5	15/07/07 - 30/07/07
	6	5	15/09/07 - 30/09/07
	6	4	22/11/06 - 22/12/06
	6	4	07/01/07 - 13/02/07
Janusz Gluza	6	11	05/02/07 - 09/02/07
	6	11	22/07/07 - 27/07/07
	6	5	25/06/07 - 26/06/07
Maria Krawczyk	6	9	08/10/06 - 12/10/06
	6	9	26/03/07 - 31/03/07
	6	4	05/02/07 - 08/02/07
Mikolaj Misiak	6	4	24/09/07 -26/09/07
	6	9	09/09/07 - 23/09/07
Agnieszka Wapienik	6	4	22/11/06 - 22/12/06
	6	4	07/01/07 - 13/02/07
Henryk Czyż	6	4	15/10/07-15/12/07
	6	4	15/01/08-15/02/08
	6	5	01/07/08-15/07/08

Janusz Gluza	6	11	15/06/08 - 21/06/08
Krzysztof Kajda	6	11	15/06/08 - 21/06/08
Konstantin A. Kanishev	6	9	21/01/08 - 02/02/08
Maria Krawczyk	6	9	01/10/07-31/10/07
	6	9	01/01/08-28/02/08
Agnieszka Wapienik	6	4	10/11/07 - 10/12/07
S. Wycech	6	7	24-1/10/2007
Mikko Sainio	7	9	7-8/12/2006
Johan Bijnens	7	11 (Mainz)	16-17/1/2007
Jan Eeg	7	10 (Ljubljana)	8-26/1/2007
Jan Eeg	7	10 (Ljubljana)	26/2-13/3/2008
Mikko Sainio	7	9 (Berne)	27-28/2/2008
Emilie Passemar	8	2	2-7 Nov 2006
Sébastien Descotes-Genon	8	11	5-7 Mar 2007
Marc Knecht	8	11	5-7 Mar 2007
Jan Stern	8	11	5-7 Mar 2007
Damir Becirevic	8	9	Sep 2007
Roland Kaiser	8	11	20 Nov - 1 Dec 2006
Hagop Sazdjian	8	1	April 2007
D. Bećirević	8	10	6/4/08 - 19/4/08
M. Brinet	8	11	5.12.-19.12.05
S. Descotes-Genon	8	5	11/6/08 - 15/6/08
B. Haas	8	5	1/6/08-28/6/08
B. Moussallam	8	5	11/6/08 - 14/6/08
N. Offen	8	4	14/9/07 - 23/9/07
	8	4	24/1/08 - 26/1/08
	8	4	18/2/08 - 22/2/08
	8	5	8/9/08 - 13/9/08
L. Oliver	8	2	16/4/08 - 19/4/08
O. Pene	8	11	11.10.-17.10.07
H. Sazdjian	8	5	February 08 (1 week)
Stefan Dürr	9	3	24.1.07 – 26.1.07
Christoph Greub	9	11	1.3.07 – 31.7.07
Christopher Smith	9	3	2.5.07 – 4.5.07
Gilberto Colangelo	9	11 (Mainz)	25-26 June 2008
Jürg Gasser	9	11 (Bonn)	28.1.-11.2. 2008
			16.6. - 28. 6. 2008
			28.7.-1.8. 2008
Christoph Greub	9	11 (DESY-H)	16.-27.1.08
Helmut Neufeld	10	5	17-23 May 2007
Andreas Kastner	10	5	12-16 May 2008
Paul Posch	10	5	12-16 May 2008
Martin Zdráhal	10	5	12-16 May 2008

Martin Zdráhal	10	8	6-9 July 2008
Gerhard Ecker	10	4	8-9 July 2008
Nejc Košnik	10	8	3-10 June 2008
Björn Leder	11	9	17/9/07 – 20/9/07
Rainer Sommer	11	5	29/5/07 – 31/5/07
B. Blossier	11	8	13.11.-16.11.07
B. Blossier	11	8	10.03.08
B. Blossier	11	8	01.04.-04.04.08
G. Herdoiza	11	5	12.12-14.12.07
G. Herdoiza	11	8	04.03-07.03.08
G. Herdoiza	11	5	18.06-23.06.08
Germán Rodrigo	1	3 (IPPP, Durham)	21 Sep - 13 Oct 2008
Germán Rodrigo	1	5 (LNF, Frascati)	5 - 8 Apr 2009
Germán Rodrigo	1	4 (TU, Munich)	9 - 11 Jul 2009
Antonio Pich	1	9 (CERN)	21 - 22 Oct 2008
Antonio Pich	1	4 (TTP Karlsruhe)	10 - 13 Sep 2009
Emilie Passemar	1	8 (IPN-Orsay)	12th - 17th November 2009
Emilie Passemar	1	8 (IPN-Orsay)	7th - 27th March 2010
Emilie Passemar	1	9 (ITP-Bern)	13th - 19th August 2010
Oscar Catà	1	10 (U. Ljubljana)	9th - 13th December 2009
Oscar Catà	1	5 (INFN-Napoli)	25th - 30th January 2010
Oscar Catà	1	5 (INFN-Napoli)	23rd - 27th February 2010
Oscar Catà	1	5 (INFN-Napoli)	16th - 19th May 2010
Oscar Catà	1	5 (INFN-Napoli)	3rd - 6th August 2010
Jorge Portolés	1	10 (U. Vienna)	27th June - 4th July 2010
Germán Rodrigo	1	2 (U. Granada)	28th - 30th October 2009
Germán Rodrigo	1	4 (U. Karlsruhe)	21st - 27th January 2010
Joaquim Prades	2	7 (Lund)	15 Oct - 16 Nov 2008
Jose Rodriguez-Quintero	2	8 (LPT-Orsay)	18th - 21th November 2009
Jose Rodriguez-Quintero	2	8 (LPT-Orsay)	30th June- 1th July 2010
Jose Rodriguez-Quintero	2	8 (LPT-Orsay)	18th July- 1th August 2010
Diogo Boito	2	8 (IPN-Orsay)	15th April- 15th July 2010
Miguel Angel Escobedo	2	4 (Munich)	2nd-6th December 2010
Aoife Bharucha	3	4 (TUM)	1 Feb - 31 Mar 2009
Vicent Mateu	4	1 (Valencia)	13-17 Oct 2008
Vicent Mateu	4	9 (Bern)	22 - 26 Sep 2008
Vicent Mateu	4	1 (Valencia)	2 - 6 Feb 2009

Alexander Khodjamirian	4	8 (Orsay)	14 -18 Feb 2009
Ulrich Nierste	4	11 (Berlin)	4 - 5 May 2009
Susanne Westhoff	4	11 (Mainz)	28 - 29 May 2009
Martin Beneke	4	3 (Southampton)	13th - 15th Dec 2009
Martin Beneke	4	9 (Zurich)	6th -8th Jan 2010
Martin Beneke	4	9 (CERN)	21st -25th Jun 2010
Andreas Crivellin	4	9 (CERN)	4th - 9th Jan 2010
Andreas Crivellin	4	10 (Lubljana)	21th - 26st Feb 2010
Thorsten Ewerth	4	9 (U Bern)	10th - 14th May 2010
Jennifer Girrbach	4	9 CERN	14th - 16th Dec 2009
Jennifer Girrbach	4	9 CERN	4th - 6th Jan 2010
Ulrich Nierste	4	9 (CERN)	15th Oct 2009 - 15th Jan 2010
Ulrich Nierste	4	9 (ITP-Bern)	20th - 21st Oct 2009
Ulrich Nierste	4	11 (U Mainz)	9th - 10th Feb 2010
Ulrich Nierste	4	6 (U Warsaw)	27th - 31st Mar 2010
Matthias Steinhauser	4	6 (U Warsaw)	10th - 15th Jan 2010
Tobias Huber	4	10 (Lubljana)	20th - 22nd Jan 2010
David Straub	4	5 (Pisa)	30 Nov - 2 Dec 2009
Stefan Recksiegel	4	10 (Lubljana)	14th - 16th Apr 2010
Pablo Roig Garces	5	4 (Munich)	17 Jan - 5 Apr 2009
Pablo Roig Garces	5	4 (Munich)	10 Apr - 10 May 2009
Pablo Roig Garces	5	4 (Munich)	20 May - 30 Sep 2009
Jernej Fesel Kamenik	5	8 (Orsay)	2 - 8 Nov 2008
Jernej Fesel Kamenik	5	4 (Karlsruhe)	14 - 19 Dec 2008
Jernej Fesel Kamenik	5	4 (Karlsruhe)	14 - 20 Apr 2009
Jernej Fesel Kamenik	5	10 (Lubljana)	16 May - 7 June 2009
Nora Brambilla	5	4 (Munich)	29 Sep - 3 Oct 2008
Antonio Vairo	5	4 (Munich)	29 Sep - 3 Oct 2008
Matthew Moulson	5	9 (CERN)	1 - 8 Oct 2008
Federico Mescia	5	8 (Orsay)	2 - 8 Nov 2008
Olga Shekhovtsova	5	1 (Valencia)	1 - 7 Feb 2009
Oscar Catà	5	4 (Munich)	23 - 27 Feb 2009
Silvano Simula	5	9 (Bern)	20 - 22 Apr 2009
Vittorio Lubicz	5	9 (Bern)	20 - 22 Apr 2009
Olga Shekhovtsova	5	4 (Munich)	28 Apr - 8 May 2009
Silvano Simula	5	10 (Wien)	4 - 9 May 2009
David Palao	5	1 (Valencia)	26th Jan - 2nd Feb 2010
David Palao	5	1 (Valencia)	26th Jul - 18th Aug 2010
David Palao	5	2 (Barcelona)	14th Sep - 18th Sep 2010
Gino Isidori	5	4 (Munich)	4th Jan - 29th Jan 2010
Gino Isidori	5	4 (Munich)	3rd Apr - 23rd Apr 2010

Gino Isidori	5	4 (Munich)	2nd May - 12th May 2010
Gino Isidori	5	4 (Munich)	10th Jun - 15th Jul 2010
Giancarlo Rossi	5	11 (Zeuthen)	1st Jul - 31st Jul 2010
Giancarlo Rossi	5	9 (CERN)	1st Aug - 31st Aug 2010
Olga Shekhovtsova	5	1 (Valencia)	14th May - 17th May 2010
Nazario Tantalo	5	8 (Orsay)	20th Jan - 24th Jan 2010
Henryk Czyż	6	4(Karlsruhe)	20.11-19.12 2008
Henryk Czyż	6	4(Karlsruhe)	15.01-15.02 2009
Henryk Czyż	6	5(INFN, Bologna)	17.09-06.10 2009
Michał Gunia	6	4(Karlsruhe)	15.01-15.02 2009
Sergiy Ivashyn	6	4(Karlsruhe)	11.01-10.02 2009
Mikołaj Misiak	6	4(Karlsruhe)	9.06-14.07 2009
Henryk Czyż	6	1 (IFIC)	21st Oct. - 22th Nov. 2009
Henryk Czyż	6	4 (KIT)	23rd Nov. - 22nd Dec. 2009
Henryk Czyż	6	4 (KIT)	11th Jan. - 10th Feb. 2010
Janusz Gluza	6	11 (Zeuthen)	31st Jan. - 6th Feb. 2010
Sergiy Ivashyn	6	1 (IFIC)	22nd Oct. - 18th Nov. 2009
Sergiy Ivashyn	6	4 (KIT)	11th Jan. - 10th Feb. 2010
Sergiy Ivashyn	6	5 (LNF)	14th April - 22nd April 2010
Sergiy Ivashyn	6	5 (LNF)	25th May - 2nd June 2010
Sergiy Ivashyn	6	11 (U.Mainz)	14th June - 25th July 2010
Mikołaj Misiak	6	9 (CERN)	1st Sept. - 21 Sept. 2010
Michał Poradziński	6	4 (KIT)	6th April - 29 June 2010
Michał Poradziński	6	4 (KIT)	6th July - 1st August 2010
Johan Bijnens	7	1 (Valencia)	12 - 14 Oct 2008
Jan Eeg	7	10 (Ljubljana)	4 - 8 May 2009
Johan Bijnens	7	2 (U. Granada)	17-27 February 2010
Johan Bijnens	7	10 (U. Vienna)	26-30 November 2009
Ilaria Jemos	7	10 (U. Vienna)	26-30 November 2009
Karol Kampf	7	8 (U. Prague)	28-30 December 2009
Karol Kampf	7	8 (U. Prague)	7 days during 12/7-6/2010

N. Offen	8	1 (Valence)	2 - 6 Feb 2009
E. de Rafael	8	1 (Valence)	1 - 6 Feb 2009
M. Knecht	8	1 (Valence)	1 - 6 Feb 2009
K. Kampf	8	1 (Valence)	1 - 6 Feb 2009
J. Trnka	8	1 (Valence)	1 - 6 Feb 2009
E. de Rafael	8	2 (Barcelona)	8 - 10 Feb 2009
L. Lellouch	8	2 (Barcelona)	22 - 24 Feb 2009
L. Oliver	8	2 (Barcelona)	15 - 18 Apr 2009
S. Descotes-Genon	8	3 (Durham)	23 - 26 Sep 2008
N. Offen	8	3 (Durham)	21 - 26 Sep 2008
N. Offen	8	4 (Siegen)	3 - 7 Nov 2008
N. Offen	8	4 (Siegen)	25 - 30 Nov 2008
H. Sazdjian	8	4 (München)	24 - 27 Feb 2009
N. Offen	8	4 (Siegen)	4 - 8 May 2009
A. Tayduganov	8	4 (Karlsruhe)	6 - 18 Sep 2009
B. Malaescu	8	4 (Karlsruhe)	6 - 18 Sep 2009
B. Haas	8	5 (Rome)	25 Jan - 4 Feb 2009
L. Lellouch	8	5 (Rome)	7 - 8 May 2009
T.N. Pham	8	5 (Bari)	15 - 21 Jun 2009
J. Charles	8	9 (CERN)	13 - 14 Nov 2008
L. Lellouch	8	9 (Bern)	20 - 22 Apr 2009
V. Bernard	8	9 (Bern)	6 - 10 Jul 2009
S. Descotes-Genon	8	9 (CERN)	10 - 11 Dec 2008
R. Garcia-Martin	8	9 (Bern)	5 - 10 Jul 2009
H. Sazdjian	8	10 (Vienna)	18 - 22 May 2009
B. Blossier	8	11 (Zeuthen)	27 - 30 Apr 2009
Veronique Bernard	8	4 (Munich)	7th September - 10th September 2010
Benoit Blossier	8	11 (DESY-Zeuthen)	17th May - 19th May 2010
Benoit Blossier	8	4 (Munich)	7th September - 10th September 2010
Sebastien Descotes-Genon	8	5 (INFN-Bari)	8th November - 12th November 2009
Sebastien Descotes-Genon	8	4 (Munich)	7th September - 12th September 2010
Sebastien Descotes-Genon	8	3 (Durham)	14th September - 17th September 2010
Samuel Friot	8	4 (Munich)	7th September - 10th September 2010
Karol Kampf	8	4 (Munich)	7th September - 10th September 2010

Marian Kolesar	8	4 (Munich)	7th September - 10th September 2010
Laurent Lellouch	8	3 (Univ. Southampton)	13th December - 16th December 2009
Laurent Lellouch	8	5 (INFN-Bari)	8th November - 12th November 2009
Laurent Lellouch	8	9 (CERN)	18th July - 7th August 2010
Laurent Lellouch	8	4 (Munich)	7th September - 10th September 2010
Bachir Moussallam	8	4 (Munich)	7th September - 10th September 2010
Tri-Nang Pham	8	5 (INFN-Bari)	19th June - 23 June 2010
Eduardo de Rafael	8	2 (Univ. Barcelona)	15th April - 19th April 2010
Alberto Ramos	8	5 (INFN-Bari)	8th November - 12th November 2009
Alberto Ramos	8	3 (Univ. Southampton)	13th December - 16th December 2009
Alberto Ramos	8	4 (Munich)	7th September - 12th September 2010
Pablo Roig-Garcès	8	5 (INFN-Bari)	8th November - 12th November 2009
Pablo Roig-Garcès	8	1 (IFIC-Valencia)	18th November - 30th November 2009
Pablo Roig-Garcès	8	1 (IFIC-Valencia)	11th April - 17th April 2010
Pablo Roig-Garcès	8	1 (IFIC-Valencia)	2nd June - 6th June 2010
Pablo Roig-Garces	8	4 (Munich)	7th September - 10th September 2010
Hagop Sazdjian	8	5 (INFN-Bari)	19th June - 23 June 2010
Andrei Tayduganov	8	4 (KIT-Karlsruhe)	6th September - 18th September 2009
Andrei Tayduganov	8	4 (Munich)	7th September - 10th September 2010
Guillaume Toucas	8	5 (INFN-Bari)	8th November - 12th November 2009
Guillaume Toucas	8	9 (Bern)	20th June - 3rd July 2010
Guillaume Toucas	8	4 (Munich)	7th September - 10th September 2010
Martin Zdrahal	8	4 (Munich)	7th September - 10th September 2010
Gilberto Colangelo	9	11 (Desy-Hamburg)	25-27 Jan 2009

Christoph Greub	9	11 (Desy-Hamburg)	23 Jan - 1 Feb 2009
Christoph Greub	9	4 (Karlsruhe)	12 Feb - 13 Feb 2009
Christoph Greub	9	11 (Desy-Hamburg)	8 - 9 Apr 2009
Tobias Hurth	9	2 (Barcelona)	6 - 8 Oct 2008
Tobias Hurth	9	8 (Marseille)	1 - 4 Dec 2008
Emilie Passemar	9	10 (Wien)	12 - 17 Oct 2008
Emilie Passemar	9	8 (IPN-Orsay)	2 - 7 Jan 2009
Emilie Passemar	9	8 (IPN-Orsay)	12 - 17 Apr 2009
Emilie Passemar	9	5 (INFN-Frascati)	6 - 12 Sep 2009
Volker Pilipp	9	4 (Karlsruhe)	23 - 25 Apr 2009
Juerg Gasser	9	10 (Wien)	11th - 24th Oct 2009
Juerg Gasser	9	10 (Wien)	22nd Nov - 5th Dec 2009
Peter Stoffer	9	1 (Valencia)	6th - 11th April 2010
Stefan Lanz	9	7 (Lund)	1. February - 31. July 2010
Martin Zdrahal	10	8 (Marseille)	14 - 19 Dec 2008
Beatrix Hiesmayr	10	5 (Frascati)	9 - 10 Apr 2009
Martin Zdrahal	10	8 (Prague)	24 - 26 May 2009
Jure Zupan	10	4 (RWTH Aachen)	28 May 2009
Nejc Kosnik	10	8 (IPN-Orsay)	14 - 21 Jun 2009
Martin Zdrahal	10	9 (PSI and Bern)	26 Jun - 10 Jul 2009
Helmut Neufeld	10	4 (TU Munich)	13 - 17 Jul 2009
Svjetlana Fajfer	10	7 (U. Oslo)	20th - 24th September 2010
Beatrix Hiesmayr	10	5 (INFN Frascati)	3rd - 5th December 2009
Pere Masjuan	10	2 (UA Barcelona)	9th - 15th October 2009
Pere Masjuan	10	2 (UA Barcelona)	12th - 18th November 2009
Pere Masjuan	10	2 (UA Barcelona)	4th - 9th December 2009
Pere Masjuan	10	2 (UA Barcelona)	19th - 22nd February 2010
Pere Masjuan	10	2 (UA Barcelona)	4th - 12th June 2010
Dmitri Melikhov	10	5 (INFN Frascati)	2nd - 13th November 2009
Helmut Neufeld	10	9 (CERN)	10th - 12th December 2009
Helmut Neufeld	10	4 (TU Munich)	7th - 11th September 2010
H. Wittig	11	10 (Uni Bern)	20 - 22 Apr 2009
A. Jüttner	11	10 (Uni Bern)	20 - 22 Apr 2009
D. Renner	11	1 (Groningen)	23 - 25 Sep 2009
D. Renner	11	8 (Grenoble)	6 - 12 Oct 2008
D. Renner	11	8 (Grenoble)	18 - 21 Mar 2009

K. Jansen	11	8 (Orsay)	20 - 21 Jan 2009
K. Jansen	11	8 (Grenoble)	18 - 21 Mar 2009
K. Jansen	11	1 (Groningen)	23 - 25 Sep 2009
S. Dinter	11	1 (Groningen)	23 - 25 Sep 2009
G. Herdoiza	11	1 (Valencia)	1 - 7 Feb 2009
G. Herdoiza	11	8 (Grenoble)	18 - 21 Mar 2009
G. Herdoiza	11	1 (Groningen)	23 - 25 Sep 2009
F. Goertz	11	4 (Karlsruhe)	7 - 18 Sep 2009
T. Pfoh	11	4 (Karlsruhe)	7 - 18 Sep 2009
Bastian Kubis	11	2 (Barcelona)	17th – 19th June 2010
Sebastian Schneider	11	9 (Bern)	6th June – 3rd July 2010
Akaki Rusetsky	11	8 (Paris)	16th – 17th February 2010
John Bulava	11	9 (CERN)	17th Jul – 13th Aug 2010
John Bulava	11	4 (Aachen)	12th - 13th July 2010
Rainer Sommer	11	9 (CERN)	17th Jul – 13th Aug 2010
Rainer Sommer	11	4 (Aachen)	12th - 14th July 2010
Ulli Wolff	11	9 (CERN)	17th - 24th July 2010
Stefan Schaefer	11	9 (CERN)	8th Jan – 13th Jan 2010
Stefan Schaefer	11	1 (Valencia)	24th Jun – 26th Jun 2010
Stefan Schaefer	11	9 (CERN)	18th Jul – 21th Jul 2010
Stefan Schaefer	11	9 (CERN)	28th Jul – 13th Aug 2010
Michael Donnellan	11	3 (Southampton)	14th - 15th December 2009
Michael Donnellan	11	4 (Aachen)	12th - 13th July 2010
Gregorio Herdoiza	11	2 (Barcelona)	13th – 18th Sept 2010
Gregorio Herdoiza	11	5 (Rome II)	24th – 30th Nov 2009
Gregorio Herdoiza	11	9 (CERN)	25th – 30th July 2010
Vincent Drach	11	2 (Barcelona)	15th – 17th Sept 2010
Dru Renner	11	8 (Orsay)	29th – 30th April 2010
Jochen Heitger	11	3 (Southampton)	8th – 11th March 2010
Jochen Heitger	11	9 (CERN)	6th - 13th Aug 2010
Karl Jansen	11	2 (Barcelona)	15th – 17th Sept 2010
Francesco Virotta	11	5 (Bari)	9th - 11th Nov 2009
Francesco Virotta	11	3 (Southampton)	14th - 15th Dec 2009
Francesco Virotta	11	4 (München)	8th - 10th Sept 2010

Collaborations among the different nodes have resulted in several joint publications. We present the list of our common publications in the form of a matrix in Tabs. 14–17 in order to display the networking aspect.

	1	2	3	4	5	6	7	8	9	10	11
1		[4,6,16, 23–25, 29,193]	[29]	[10, 29, 37, 193, 387]	[14, 15, 29, 30, 34–36, 193, 387, 542, 556, 1110]			[14, 15, 29, 193, 767, 1111]	[7, 8, 13, 19,29]	[7,29]	[14, 15, 19,29]
2	[4, 6, 16, 23–25,29, 193]		[29, 174, 175, 194, 195, 301]	[29, 193, 381]	[29, 181, 193, 196, 545]		[197, 198]	[29, 180, 193, 762, 1112]	[29]		[29]
3	[29]	[29,174, 175, 194, 195, 301]		[29]	[29]			[29]	[29]		[29]
4	[10, 29, 37, 193, 387]	[29,193, 381]	[29]		[29, 193, 387, 393, 394, 394, 543, 544, 1113–1125]	[371, 659, 660, 663]		[29,193]	[29,659]		[29, 412, 659]
5	[14, 15, 29, 30, 34–36, 193, 387, 542, 556, 1110]	[29,181, 193, 196, 545]	[29]	[29, 193, 387, 393, 394, 394, 543, 544, 1113–1125]				[14, 15, 29, 193, 538–541, 765, 773, 1126–1129]	[29, 866, 867, 873, 964,965]	[924]	[14, 15, 29, 538, 964, 965, 1130–1135]
6				[371, 659, 660, 663]			[731]		[659, 661]		[656–659]
7		[197, 198]				[731]			[726]	[710, 711]	
8	[14, 15, 29, 193, 767, 1111]	[29,180, 193, 762, 1112]	[29]	[29,193]	[14, 15, 29, 193, 538–541, 765, 773, 1126–1129]				[29,770]		[14, 15, 29, 759, 768]
9	[7, 8, 13, 19,29]	[29]	[29]	[29,659]	[29, 866, 867, 873, 964,965]	[659, 661]	[726]	[29,770]		[924]	[19, 869, 953, 957, 964–966, 973, 1130–1135]
10	[7,29]				[924]		[710, 711]		[924]		
11	[14, 15, 19,29]	[29]	[29]	[29, 412, 659]	[14, 15, 29, 538, 964, 965, 1130–1135]	[656–659]		[14, 15, 29, 759, 768]	[19, 869, 953, 957, 964–966, 973, 1130–1135]		

Table 14: Joint publications of several nodes during the first year of the reporting period.

	1	2	3	4	5	6	7	8	9	10	11
1	**29**	[56, 60, 73, 199]	[310]	[37, 45, 53, 431–435]	[14, 49, 52, 303, 557–559]	[678]		[14, 15, 52]	[14, 52, 59, 61]		[14, 50, 52, 57, 59]
2	[56, 60, 73, 199]	**19**		[29, 56, 208, 303, 431–435, 439]	[303]	[678]		[70]			
3	[310]		**20**	[45, 303]	[303, 597–601]	[678]		[801, 802]			[305, 308, 322–324]
4	[37, 45, 53, 431–435]	[29, 56, 208, 303, 431–435, 439]	[45, 303]	**38**	[29, 45, 303, 431–438, 442, 567, 594–596]	[45, 303, 680, 681]		[29, 45, 303, 418, 431–435]	[29, 45, 303]		[29, 45, 412, 434, 435]
5	[14, 49, 52, 303, 557–559]	[303]	[303, 597–601]	[29, 45, 303, 431–438, 442, 567, 594–596]	**26**	[677, 678, 682]	[568]	[14, 15, 52, 303, 563, 566, 568, 597–601, 793, 798, 808]	[303, 566, 591]	[585–588]	[14, 52, 557–559, 793, 984, 987]
6	[678]	[678]	[678]	[45, 303, 680, 681]	[677, 678, 682]	**8**		[678]	[678, 684]		[665–670, 684]
7					[568]		**5**	[568]	[568]	[585]	
8	[14, 15, 52]	[70]	[801, 802]	[29, 45, 303, 418, 431–435]	[14, 15, 52, 303, 563, 566, 568, 597–601, 793, 798, 808]	[678]	[568]	**20**	[14, 15, 52, 563, 568, 783, 785, 793, 809–811]	[588, 786, 797]	[14, 15, 52, 568, 789, 790, 790, 803, 1001]
9	[14, 52, 59, 61]			[29, 45, 303]	[303, 566, 591]	[678, 684]	[568]	[14, 15, 52, 563, 568, 783, 785, 793, 809–811]	**17**		[50, 59, 298, 883, 965, 981, 988–992, 1016]
10					[585–588]		[585]	[588, 786, 797]		**4**	
11	[14, 50, 52, 57, 59]		[305, 308, 322–324]	[29, 45, 412, 434, 435]	[14, 52, 557–559, 793, 984, 987]	[665–670, 684]		[14, 15, 52, 568, 789, 790, 790, 803, 1001]	[50, 59, 298, 883, 965, 981, 988–992, 1016]		**33**

Table 15: Joint publications of several nodes during the second year of the reporting period. See Tab. 14 for explanation.

	1	2	3	4	5	6	7	8	9	10	11
1	**33**	[82–84, 87, 123–125, 227, 241, 602]	[112, 242, 325, 333]	[87, 97, 98, 100, 101, 112]	[104, 112–114, 123–125, 602]			[112, 113, 123–125, 602]	[112, 602]	[85, 112]	[112, 113, 117, 119, 602, 1046]
2	[82–84, 87, 123–125, 227, 241, 602]	**24**		[87, 228]	[221–223, 228, 246, 602]			[70, 173, 226, 240, 246, 602]	[602]		[602]
3	[112, 242, 325, 333]		**21**	[112, 325, 329, 331]	[112, 325, 333, 334, 341]			[112, 333]	[112, 346]	[112]	[112, 331, 345, 346, 348]
4	[87, 97, 98, 100, 101, 112]	[87, 228]	[112, 325, 329, 331]	**48**	[112, 477, 484, 488, 612–615, 632]	[483]		[112, 464]	[112, 456, 497, 901, 902]	[112]	[112, 331]
5	[104, 112–114, 123–125, 602]	[221–223, 228, 246, 602]	[112, 325, 333, 334, 341]	[112, 477, 484, 488, 612–615, 632]	**22**		[607]	[112, 246, 602, 604, 606, 626, 848]	[112, 602, 606, 609, 616, 848]	[112, 607, 608, 630, 631, 934]	[112, 602, 616, 626, 1022, 1030]
6				[483]		**6**	[686, 687]	[685]			[689, 692, 693]
7					[607]	[686, 687]	**8**			[607]	
8	[112, 113, 123–125, 602]	[70, 173, 226, 240, 246, 602]	[112, 333]	[112, 464]	[112, 246, 602, 604, 606, 626, 848]	[685]		**33**	[112, 602, 816, 817, 820, 821, 834, 835, 845, 846]	[112, 816, 817]	[112, 113, 602, 626, 834, 835, 1036, 1046, 1136]
9	[112, 602]	[602]	[112, 346]	[112, 456, 497, 901, 902]	[112, 602, 606, 609, 616, 848]			[112, 602, 816, 817, 820, 821, 834, 835, 845, 846]	**6**	[112, 816, 817]	[112, 113, 346, 602, 609, 834, 835, 887, 890, 898]
10	[85, 112]		[112]	[112]	[112, 607, 608, 630, 631, 934]		[607]	[112, 816, 817]	[112, 816, 817]	**5**	[112, 1034, 1059]
11	[112, 113, 117, 119, 602, 1046]	[602]	[112, 331, 345, 346, 348]	[112, 331]	[112, 602, 616, 626, 1022, 1030]	[689, 692, 693]		[112, 113, 602, 626, 834, 835, 1036, 1046, 1136]	[112, 113, 346, 602, 609, 834, 835, 887, 890, 898]	[112, 1034, 1059]	**49**

Table 16: Joint publications of several nodes within the third year of the network. The diagonal elements (boxed boldface numbers) are the number of publications which the corresponding node wrote without participation of other nodes.

	1	2	3	4	5	6	7	8	9	10	11
1	**19**	[128, 133–135, 144, 158–164]	[128, 142, 160–163, 355]	[127, 128, 142, 158–163, 533]	[128, 130, 132, 141, 142, 144, 148, 149, 154, 155, 158–163, 165–171]	[128, 142, 160–163]	[172]	[142, 146, 147, 150, 151, 158, 159, 173]	[128, 132, 142, 146, 152–155, 158–163, 165–172]	[128, 130, 144, 158–163, 653]	[132, 142, 144, 154, 155, 158, 159, 165–171]
2	[128, 133–135, 144, 158–164]	**8**	[128, 160–163, 253, 254]	[128, 158–163, 260, 261, 533]	[128, 144, 158–163]	[128, 160–163]		[158, 159, 256]	[128, 158–163, 912, 913, 1137]	[128, 144, 158–163]	[144, 158, 159, 912, 913, 1137]
3	[128, 142, 160–163, 355]	[128, 160–163, 253, 254]	**21**	[128, 142, 160–163, 352, 353, 367, 532, 533, 536]	[128, 142, 160–163, 360, 366, 367]	[128, 142, 160–163]		[142, 352, 532, 533]	[128, 142, 160–163, 352, 1138, 1139]	[128, 160–163]	[142, 352, 366, 1139]
4	[127, 128, 142, 158–163, 533]	[128, 158–163, 260, 261, 533]	[128, 142, 160–163, 352, 353, 367, 532, 536]	**15**	[128, 142, 158–163, 367, 510, 513, 518, 526, 527, 533, 639, 641]	[128, 142, 160–163, 511, 519]		[142, 158, 159, 352, 521, 532, 533]	[128, 142, 158–163, 352, 510, 515, 536]	[128, 130, 144, 158–163]	[142, 158, 159, 352, 366, 510]
5	[128, 130, 132, 141, 142, 144, 148, 149, 154, 155, 158–163, 165–171]	[128, 144, 158–163]	[128, 142, 160–163, 360, 366, 367]	[128, 142, 158–163, 367, 510, 513, 518, 526, 527, 533, 639, 641]	**14**	[128, 142, 160–163]		[142, 158, 159, 1138]	[128, 132, 142, 154, 155, 158–163, 165–171, 646–648, 1138, 1140]	[128, 144, 158–163, 630, 653, 937–940, 946]	[132, 142, 144, 154, 155, 158, 159, 165–171, 366, 1138]
6	[128, 142, 160–163]	[128, 160–163]	[128, 142, 160–163]	[128, 142, 160–163, 511, 519]	[128, 142, 160–163]	**10**		[142]	[128, 142, 160–163]	[128, 160–163, 950]	[142, 699, 701]
7	[172]						**5**	[747, 854]	[172, 751]	[751]	
8	[142, 146, 147, 150, 151, 158, 159, 173]	[158, 159, 256]	[142, 352, 532, 533]	[142, 158, 159, 352, 521, 532, 533]	[142, 158, 159, 1138]	[142]	[747, 854]	**12**	[142, 146, 158, 159, 352, 1138]	[158, 159, 937]	[142, 158, 159, 352, 853, 859–861, 1082, 1138]
9	[128, 132, 142, 146, 152–155, 158–163, 165–172]	[128, 158–163, 912, 913, 1137]	[128, 142, 160–163, 352, 1138, 1139]	[128, 142, 158–163, 352, 510, 515, 536]	[128, 132, 142, 154, 155, 158–163, 165–171, 646–648, 1138, 1140]	[128, 142, 160–163]	[172, 751]	[142, 146, 158, 159, 352, 1138]	**5**	[128, 158–163]	[132, 142, 154, 155, 158, 159, 165–171, 352, 912, 913, 1081, 1088, 1137–1139, 1141]
10	[128, 144, 158–163, 653]	[128, 144, 158–163]	[128, 160–163]	[128, 130, 144, 158–163]	[128, 144, 158–163, 630, 653, 937–940, 946]	[128, 160–163, 950]	[751]	[158, 159, 937]	[128, 158–163]	**11**	[144, 158, 159]
11	[132, 142, 144, 154, 155, 158, 159, 165–171]	[144, 158, 159, 912, 913, 1137]	[142, 352, 366, 1139]	[142, 158, 159, 352, 366, 510]	[132, 142, 144, 154, 155, 158, 159, 165–171, 366, 1138]	[142, 699, 701]		[142, 158, 159, 352, 853, 859–861, 1082, 1138]	[132, 142, 154, 155, 158, 159, 165–171, 352, 912, 913, 1081, 1088, 1137–1139, 1141]	[144, 158, 159]	**18**

Table 17: Joint publications of several nodes within the fourth year of the network. See Tab. 16 for explanation.

3.9 Changes to the schedule

We have moved the second general meeting, *Euro-Flavour 07* from month 12 to month 14, because several other conferences in spring and summer have been used for networking, as mentioned in Sects. 3.6. Another reason was a scheduling conflict with the *4th International Conference On Flavor Physics* in Beijing. The duration of the second, third and fourth European School on Flavour Physics have been extended to 12 days; this has allowed us to schedule a broader set of lectures covering all relevant aspects of flavour physics and to complement the lectures with tutorials . We have further hired several ER and ESR later than originally envisaged. The reason for this delay was an unfortunate timing of the start of the contract. In theoretical particle physics it is customary to hire staff at the beginning of the academic fall/winter term, and the hiring decisions are usually made more than six months in advance in December or January. Our search for ERs and ESRs started in late January 2007 at a time when most qualified young researchers had already decided on their job offers.

4 Economic spin–off

The experimental CDF group in node 4 has developed neural-network software for the original purpose to identify signal events over a large number of background processes in collider experiments. For example, their neural-network method was used in the measurement of the $B_s - \overline{B}_s$ oscillations at CDF and is currently used to analyse BELLE data. As a spin-off the company <*phi-t*>, which applies neural-network technology to data mining, was founded in October 2002. The rapidly growing company frequently hires former PhD students who worked in the B physics group of the CDF experiment. A <*phi-t*> speaker participated in our School on Flavour physics 2009. For more information see `http://www.phi-t.de`.
Researchers in node 8 (CNRS) have taken part in the development of parallel computers dedicated to lattice computations, both at the hardware and software levels. They have collaborated with other researchers in the Flavianet network from Germany and Italy, but also with IRISA/INRIA (National Institute in Computer Sciences, Rennes, France). Some of their joint work on parallel computation has been exploited by two small enterprises. An IRISA/INRIA start-up, CAPS-Entreprise, has developped and extended softwares linked to parallel processing and to on-board processors for large-scale computations. Another enterprise, KERLABS, has exploited their expertise to develop a Linux-based operating system for computer clusters.
The theoretical work at the FLAVIA*net* nodes involves advanced computing methods. The computing skills of our PhD students makes them attractive for private enterprises. We illustrate the variety of emplyment opportunities with two examples from node 7: Niclas Danielsson (PhD in Lund) works for *Ericsson* developing physical simulations and Axel Hiorth (PhD in Oslo) applies his computing expertise to reservoir modeling for the oil industry in Stavanger.

5 Summary

FLAVIA*net* members have written more than 1000 papers for refereed journals during the report-

ing period. We estimate that the FLAVIA*net* activity corresponds to at least 3/4 of the scientific output in theoretical flavour physics in Europe. Experimentalists in FLAVIA*net* were involved in numerous analyses of data from BaBar, BELLE, KLOE, CDF, NA62 and, as a novel development, also of the LHC experiments. The visibility of FLAVIA*net* research at international conferences is evident from the large number of approximately 1100 talks given by researchers in our network. Our annual network meetings, the *Euro-Flavour* conferences, were central events of our field of research in Europe. These meetings were complemented by other workshops and conferences organised by FLAVIA*net* members at their home institutions as described in Sect. 3.7. Importantly, FLAVIA*net* funding has allowed 30 young people to do research in flavour physics through ESR and ER contracts.

It is difficult to list all highlights of four years of Flavianet research in this summary: Our Kaon working group has become the leading authority for the CKM element V_{us} and other quantities of Kaon physics. Similarly, our FLAVIA*net* Lattice Averaging Group steers the European activity in the combination of different lattice calculations for the use by phenomenologists. Studies of physics beyond the Standard Model have recently focused on two quantities which show persistent deviations from the Standard-Model prediction above the level of three standard deviations: the anomalous magnetic moment of the muon and B–$\overline{B}$ mixing. These frontiers have been extensively explored by FLAVIA*net*, from both the experimental and theoretical side. This research has overarched several nodes and has profited from the collaborative effort of theorists in four of our six working groups.

FLAVIA*net* has fostered existing and stimulated new transnational scientific cooperations, which resulted in common publications of different nodes, see Tabs. 14–17. By comparing these tables one recognises that the number of scientific collaborations has increased over the years and FLAVIA*net* has lead to a better integration of European research in flavour physics. The mutual visits listed in Sect. 3.8 have strengthened transnational ties. FLAVIA*net* has brought people and their expertises together and has actively contributed to a structured European science landscape.

Flavour physics is a field on the rise. In 2010 the largest flavour-physics experiment ever built, LHCb at CERN, has started to take data. Further the CERN experiment NA62 has begun to study Kaon decays with an unprecedented precision. The B-meson factory BELLE is currently upgraded to much higher luminosity and the BES-III facility in Beijing explores new frontiers in charm physics. It is therefore desirable that the European activity in flavour physics will be structured in a new ITN which builds on the experience of FLAVIA*net*.