First Periodic Report

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Network short title	:	European Investigations on DAΦNE and other International Collider Experiments using Effective Theories of Colours and Flavours from the Φ to the Υ
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RTN NETWORK

EURIDICE

European Investigations on DAΦNE and other
International Collider Experiments using Effective
Theories of Colours and Flavours from the Φ to the Υ

EU contract no.: ERBFMRXCT2002-0311

First Periodic Progress Report 01/09/2002 -
31/08/2003

Contents

1   <u>Part A - Research Results</u>

The EURIDICE project focuses on a precise determination of masses, coupling constants and order parameters in the Standard Model. The major theoretical and phenomenological objectives of EURIDICE, stated in Annex I of the contract, can be grouped into six main research projects, respectively:

1. **CP- violation and Cabibbo-Kobayashi-Maskawa (CKM) matrix**

2. **Chiral Perturbation Theory**

3. **Quark masses**

4. $\alpha_{em}(M_Z)$ **and the anomalous magnetic moment of the leptons**

5. **Heavy flavour decays and Heavy Quark Effective Theory (HQET)**

6. **Strong Interaction limit of QCD**

In the sections to follow, the progress achieved towards attainment of these objectives during the first period will be discussed.

1.1   A1. Scientific Highlights

In this section we summarize the main scientific results of the network during the first year of operation. The joint publications are included following a brief, necessarily incomplete, description of the main scientific content. Whenever one of the highlights refers to a joint publication, the relevant reference to Section A.2 is included. The symbol [nr], with $n = 1, 2, ...$ refers to joint papers published in a refereed journal, [nc] if published in the proceedings of a conference, [np] if still a preprint. Among the highlights there are also results from work of a single institute. In such case, the relevant publication can be found in the reports from the individual nodes, included as Annex. These highlights and hence the joint publications, are not listed in order of importance, but following the order of the relevant scientific objectives reproduced above.

1.1.1   CP- violation and Cabibbo-Kobayashi-Maskawa (CKM) matrix

To help clarify the origin of CP-violation:

CP-, T-AND CPT-VIOLATING PARAMETERS

- As part of a long-term project, the first complete analysis of isospin breaking corrections to $K \to \pi\pi$ amplitudes at NLO and their impact on the CP–direct observable ε'/ε was carried out by the Vienna and Valencia nodes [1p].

- New results [1r] were obtained in a large-N_c approach by the Marseille-Barcelona group, based upon the analytic matching between short- and long-distance scale dependences within dimensional renormalization schemes, leading, numerically, to a large positive contribution to the direct CP-violation parameter ϵ'/ϵ.

- Concerning CP–violating asymmetries, a first update on the predictions for the slope and decay rates of K to 3π, recently measured by the KLOE Collaboration [1c] was obtained by the joint Barcelona-Bern collaboration [2c].

CP violation and rare decays:

- INFN, Valencia, Paris, Bern and Warsaw [2p] studied various aspects of rare B decays, including the NNLO QCD corrections and charm quarks loop.

- A joint INFN-Barcelona collaboration has studied CP-violation in the B system [2r].

- LNF and Napoli groups have presented a new analysis of the rare decay $K_L \to \pi^0 e^+ e^-$.

- The INFN-LNF group, in collaboration with the Bern/Zurich node, has obtained significant results toward a complete NNLL analysis of $B \to X_s \ell^+ \ell^-$ [3c].

- The KLOE collaboration measured the branching ratio for the rare decay $K_L \to \gamma\gamma$ [3r].

Quantum mechanics and the neutral meson system:

- In a collaboration between Barcelona and Vienna [3p,4p], it was shown that the neutral kaon system is very suitable to discuss quantum marking and eraser operations and that a single experimental set-up for neutral kaons covers the physics of various quantum marking and eraser experiments performed with photons.

- Experimental tests of the dissipative dynamics describing the propagation of neutral kaons in randomly fluctuating media have been proposed by INFN-Trieste.

To improve the theoretical precision for the CKM matrix elements:

- Valencia and Barcelona (Granada team) obtained [4r] a new determination of the CKM matrix element $|V_{us}|$ from hadronic tau decays.

- The two-loop corrections in the isospin limit have been calculated by the Lund and Barcelona nodes [5r] closing one of the remaining obstacles in improving the experimental precision on V_{us} from semileptonic kaon decays.

- Within the framework of chiral perturbation theory with virtual photons and leptons, the extraction of the Cabibbo-Kobayashi-Maskawa (CKM) matrix element $|V_{ud}|$ from the reaction $\pi^\pm \to \pi^0 e\nu$ was discussed by the Valencia, Marseille and Vienna nodes [6r].

- On the experimental side, the KLOE collaboration has performed a preliminary measurement of $K_{L,S} \to \pi\ell\nu$ branching ratios and the related extraction of the CKM element $|V_{us}|$ [4c].

1.1.2 Chiral Perturbation Theory

To sharpen existing predictions of ChPT:

- The Bern node has investigated isospin breaking effects in low-energies effective theories from a general point of view.

- The Lund group has calculated the pion and kaon scalar form factors to two loop order.

- The implications of large-N_c and chiral symmetry for the mass spectra of meson resonances were investigated by the Vienna and Valencia nodes [7r], and it was found that, unlike for most other mesons, the mass matrix of the light scalars deviates strongly from its large-N_c limit.

- The matrix elements of $\Delta I = 3/2$ transitions in $K \to \pi\pi$ within lattice QCD was studied by the Valencia node.

- The Valencia-Marseille-Desy Zeuthen nodes, studying the long-distance behaviour of two-point functions of flavour non-singlet axial and vector currents in a finite volume, found that quenching has a dramatic effect on the vector correlator [8r].

- A calculation of the standard model $\Delta S = 2$ matrix element relevant to indirect CP violation in $K- > \pi\pi$ decays was done by the Marseille node using Neuberger's chiral formulation of lattice fermions.

- On the experimental side, the KLOE collaboration has performed a number of unprecedented precision measurements of light meson decays [9r,10r,5c,6c,7c]

To determine effective low-energy couplings from first principles:

- The parameters of the effective Chiral Lagrangian from first principles, through finite-size scaling studies in lattice QCD, has been investigated through a joint collaboration between Bern and DESY-Zeuthen [5p].

To investigate the order parameters of QCD:

- The Orsay node has progressed towards obtaining a complete solution of the Roy-Steiner equations for $\pi K \to \pi K$ and $\pi\pi \to KK$ amplitudes.

- After the earlier results on nonleptonic matrix elements, the Lund-Granada nodes started a construction of systematic ladder resummation, and a general conflict between quark counting rules, QCD short distance constraints and saturation by a finite number of resonances was found also for a class of order parameters [11r,8c].

Baryon ChPT and Hypernuclei:

- Valencia and the Barcelona nodes performed an analysis of the dynamical generation of baryonic resonances using unitary extensions of chiral perturbation theory and a new analysis of chiral meson dynamics in nuclear matter, obtaining valuable progress in hypernuclei studies and $\Lambda(1405)$ production in K–Nucleon interactions [6p,12r,9c,10c].

- The Helsinki node derived the nucleon-nucleon interaction and the associated interaction currents in the large-N_c limit of QCD, demonstrating that the operator structure of all currently used realistic phenomenological interaction models is consistent with the $1/N_c$ expansion.

- Helsinki and the Warsaw node extracted a value for the $\pi^0 - \eta$ mixing parameter [7p] from $p + d \to 3H\pi^+$ and $p + d \to 3He\pi^0$.

1.1.3 Quark masses

- The Valencia-Granada group obtained a new determination of the mass of the strange quark m_s [4r].

1.1.4 $\alpha_{em}(M_Z)$ and the anomalous magnetic moment of leptons $(g-2)_l$

$(g-2)_\mu$ and multi-loop calculations:

- The INFN-Bologna group, in collaboration with the Karlsruhe team of the DESY Zeuthen node, has obtained several new results about precise or analytic evaluations of multi-loop Feynman graphs mainly through Differential Equations [13r,14r,15r,16r,11c, 8p].

- In a collaboration between Warsaw and the INFN (Bologna) node, the work concentrated on numerical evaluation of two-loop scalar integrals relevant for precise evaluation of Standard Model observables [12c].

The electroweak contribution:

- The electroweak hadronic contribution to $(g-2)_\mu$ was reconsidered by a joint Barcelona-Marseille collaboration [17r], improving previous evaluations by the implementation of the current algebra Ward identities and the inclusion of the correct short-distance QCD behaviour of the relevant hadronic Green's function.

Hadronic Effects in electroweak precision observables

- The collaboration between the DESY/Karlsruhe and Katowice group from the Warsaw node has developed theoretical concepts which allow to utilize the Radiative Return at KLOE, CLEO-C, BABAR and BELLE for a precise measurement of the pion form factor at low Q^2 [18r,9p]. The impact of the FSR contribution on the anomalous magnetic moment of the muon was evaluated [19r]. An efficient Monte Carlo program for the simulation of massive particle production including photon radiation was developed [10p].

- The Karlsruhe group participated in the general activities of the KLOE collaboration (at DAFNE/Frascati) of data taking, data reconstruction and data analysis. The main emphasis was on measuring the cross section $e^+e^- \rightarrow \gamma\gamma^* \rightarrow \pi^+\pi^-\gamma$ at the 1% level in close collaboration with theoretical groups from Karlsruhe, Katowice and DESY Zeuthen among others. The accuracy of the measurement of the cross section for the two pion final state with a real photon emitted in the initial state as a function of energy up to the ϕ resonance is less than 0.5% for the statistical error and of the order of 1-2% for the systematic error [13c,14c,15c,16c].

- The Katowice team from the Warsaw node in collaboration with the Karlsruhe sub-node of DESY Zeuthen, developed Monte Carlo tools, to exploit a radiative return method for hadronic e^+e^- cross sections [17c,18c].

1.1.5 Heavy flavour decays and Heavy Quark Effective Theory (HQET)

- The researchers of the INFN Bari group have performed new studies on the structure of $f_0(980)$, an analysis and interpretation of the particle $D_{sJ}(2317)$, recently observed by BABAR, BELLE and CLEO Collaborations, and have studied the validity of factorization in nonleptonic B decays.

- The coupling of eta mesons to constituent quarks from the $D_s^* \rightarrow D_s\pi^0$ decay was derived by the Helsinki node.

- The introduction of a radial excitation of the D or D^* mesons was shown by the Marseille and Orsay nodes to allow for the large experimental value of the $g_{D^*D\pi}$ constant from light cone QCD sum rules [20r].

- A systematic study of soft gluonic effects, chiral corrections and $1/m_b$ effects in $B\overline{B}$ mixing has been performed by the Oslo node.

1.1.6   Strong Interaction limit of QCD

α_s in the infrared region :   The influence of models for α_s in the infrared region on the total cross-sections were studied by the INFN-LNF node and Granada team from the Barcelona node [21r,11p]. Such studies also utilize new, radiatively generated, LO quark (u,d,s,c,b) and gluon densities in a real, unpolarized photon constructed by the Warsaw-Granada collaboration [22r]. α_s

To firmly establish the new glueball spectroscopy and clarify the effect of strong interactions in heavy flavour decays :   Following fresh impetus by the discovery of candidates for states beyond the quark model, the UK group studied what recent data can teach about the hadron spectrum and dynamics, and their relation to QCD.   SPECTROSCOPY

Meson Spectroscopy beyond the naive Quark Model : The Helsinki-Bern/Zurich collaboration has been working on a review of theoretical predictions for possible four-quark states, glueballs, hybrid mesons and other non-standard quark model states [12p].

1.2 A.2 Joint Publications and Young Researcher Publications

In the following we list the joint publications by the network participants, following the order in which they appear in Section A1.1, namely according to the highlights of scientific achievements in each Objective. We distinguish between papers published in refereed journals (r), conference proceedings (c) and preprints (p). Throughout this report, references to the teams follow the description given in subsection 2.3 (**Work Plan**) in the included paragraphs dedicated to **Effort of the participants**. More details can also be found in the Annex. In the list of joint publications it is indicated which nodes and also (after the slash) which subnodes or external teams have participated.

1.2.1 Refereed Papers (r)

1r T. Hambye, S. Peris, E. de Rafael, $\Delta I = 1/2$ and ε'/ε in large $N(c)$ QCD, JHEP **0305**, 027 (2003) [hep-ph/0305104], **joint Barcelona-Marseille**.

2r R. Fleischer, G. Isidori and J. Matias, $Shedding$ $light$ on the $'dark$ $side'$ of $B - \bar{B}$ $mixing$ $through$ $B \to \pi^+\pi^-$, $K \to \pi\nu\bar{\nu}$ and $B \to \mu^+\mu^-$, JHEP **0305**, 053 (2003) [hep-ph/0302229], **joint INFN/LNF-Barcelona**.

3r M. Adinolfi et $al.$ [KLOE Collaboration], $Measurement$ of the $ratio$ $\Gamma(K_L \to \gamma\gamma)/\Gamma(K_L \to 3\pi^0)$ $with$ the $KLOE$ $detector,$ Phys. Lett. **B566**, 61 (2003) [hep-ex/0305035], **joint INFN-DESY/Karlsruhe**.

4r E. Gamiz, M. Jamin, A. Pich, J. Prades, F. Schwab, $Determination$ of m_s and $|V_{us}|$ $from$ $hadronic$ tau $decays$, JHEP **0301**, 060 (2003) [hep-ph/0212230], **joint Valencia-Barcelona/Granada**.

5r J. Bijnens and P. Talavera, $K_{\ell 3}$ $decays$ in $Chiral$ $Perturbation$ $Theory$, Nucl. Phys. **B669** 341 (2003) [hep-ph/0303103], **joint Barcelona-Lund**.

6r V. Cirigliano, M. Knecht, H. Neufeld and H. Pichl, The $pionic$ $beta$ $decay$ in $chiral$ $perturbation$ $theory$, Eur. Phys. J. **C27**, 255 (2003) [hep-ph/0209226], **joint Valencia-Marseille-Vienna**.

7r V. Cirigliano, G. Ecker, H. Neufeld, A. Pich, $Meson$ $resonances,$ $large$ N_C and $chiral$ $symmetry$, JHEP **0306**, 012 (2003) [hep-ph/0305311], **joint Valencia-Vienna**.

8r P.H. Damgaard, P. Hernández, K. Jansen, M. Laine, L. Lellouch, $Finite$ $size$ $scaling$ of $vector$ and $axial$ $current$ $correlators$, Nucl. Phys. **B656**, 226 (2003) [hep-lat/0211020], **joint Valencia-Marseille-DESY Zeuthen**.

9r A. Aloisio et $al.$ [KLOE Collaboration], $\eta,$ η' $Studies$ $with$ the $KLOE$ $Detector$ at $DAPHNE,$ Phys. Scripta **T99**, 123 (2002), **joint INFN-DESY/Karlsruhe**.

10r A. Aloisio et $al.$ [KLOE Collaboration], $Study$ of the $decay$ $\Phi \to \pi^+\pi^-\pi^0$ $with$ the $KLOE$ $detector,$ Phys. Lett. **B561**, 55 (2003) [hep-ex/0303016], **joint INFN-DESY/Karlsruhe**.

11r J. Bijnens, E. Gamiz, E. Lipartia, J. Prades, QCD $short$ $distance$ $constraints$ and $hadronic$ $approximations$, JHEP **0304**, 055 (2003) [hep-ph/0304222], **joint Barcelona/Granada-Lund**.

12r D. Jido, J.A. Oller, E. Oset, A. Ramos, U.G. Meissner, *Chiral dynamics of the two* $\Lambda(1405)$ *states*, Nucl. Phys. **A725**, 181 (2003) [nucl-th/0303062], **joint Valencia-Barcelona**.

13r M. Caffo, H. Czyz and E. Remiddi, *Numerical evaluation of the general massive 2-loop self-mass master integrals from differential equations,* Nucl. Instrum. Meth. **A502**, 613 (2003) [hep-ph/0211171], **joint INFN/Bologna-DESY/Karlsruhe-Warsaw/Katowice**.

14r P. Mastrolia and E. Remiddi, *The analytic value of a 3-loop sunrise graph in a particular kinematical configuration,* Nucl. Phys. **B657**, 397 (2003) [hep-ph/0211451], **joint INFN/Bologna-DESY/Karlsruhe**.

15r R. Bonciani, P. Mastrolia and E. Remiddi, *Vertex diagrams for the QED form factors at the 2-loop level,* Nucl. Phys. **B661**, 289 (2003) [hep-ph/0301170], **joint INFN/ Bologna-DESY/Karlsruhe**.

16r P. Mastrolia and E. Remiddi, *Two-loop form factors in QED,* Nucl. Phys. **B664**, 341 (2003) [hep-ph/0302162], **joint INFN/Bologna-DESY/Karlsruhe**.

17r M. Knecht, S. Peris, M. Perrottet, E. De Rafael, *Electroweak hadronic contributions to the muon (g-2),* JHEP **0211**, 003 (2002) [hep-ph/0205102], **joint Barcelona-Marseille**.

18r H. Czyz, A. Grzelinska, J. H. Kühn, G. Rodrigo, *The radiative return at ϕ- and B-factories: small-angle photon emission at next to leading order*, Eur. Phys. J. **C27**, 563 (2003) [hep-ph/0212225], **joint DESY/Karlsruhe-Warsaw/Katowice**.

19r J. Gluza, A. Hoefer, S. Jadach, F. Jegerlehner, *Measuring the FSR inclusive $\pi^+\pi^-$ cross-section*, Eur. Phys. J. **C28**, 261 (2003) [hep-ph/0212386], **joint DESY/ Zeuthen-Warsaw/Katowice**.

20r D. Becirevic, J. Charles, A. LeYaouanc, L. Oliver, O. Pène and J. C. Raynal, *Possible explanation of the discrepancy of the light-cone QCD sum rule calculation of $g_{D^*D\pi}$ coupling with experiment*, JHEP **0301**, 009 (2003) [hep-ph/0212177], **joint Marseille-Orsay**.

21r R. M. Godbole, A. De Roeck, A. Grau and G. Pancheri, *Hadronic cross-sections in two photon processes at a future linear collider*, JHEP **0306**, 061 (2003) [hep-ph/0305071], **joint INFN/LNF-Barcelona/Granada**.

22r F. Cornet, P. Jankowski, M. Krawczyk, A. Lorca, *A New five flavor LO analysis and parametrization of parton distributions in the real photon*, Phys. Rev. **D68**, 014010 (2003) [hep-ph/0212160], **joint Barcelona/Granada-DESY/Zeuthen-Warsaw**.

1.2.2 Conference Proceedings (c)

1c A. Aloisio *et al.* [KLOE Collaboration], *Measurement of the branching ratio for the decay $K^\pm \to \pi^\pm\pi^0\pi^0$ with the KLOE detector,* contributed paper to International Symposium on Lepton and Photon Interactions at High Energies (LP03, Batavia, Illinois, 11-16 Aug 2003) [hep-ex/0307054], **joint INFN-DESY/Karlsruhe**

2c E. Gamiz, J. Prades and I. Scimemi, *CP-violating asymmetries in $K^+ \to 3\pi$ in the standard model,* Invited Talk at the XXXVIII Rencontres de Moriond on Electroweak Interactions and Unified Theories, Les Arcs, France, 15-22 Mar 2003, [hep-ph/0305164], **joint Barcelona/Granada-Bern**.

3c A. Ghinculov, T. Hurth, G. Isidori and Y. P. Yao, *NNLL QCD corrections to the decay $B \to X_s l^+ l^-$,* Nucl. Phys. Proc. Suppl. **116**, 284 (2003) [hep-ph/0211197], **joint INFN/LNF-Bern/Zurich**.

4c A. Aloisio *et al.* [KLOE Collaboration], *KLOE prospects and preliminary results for K_{l3} decay measurements,* eConf **C0304052** (2003) WG607 [hep-ex/0307016], **joint INFN-DESY/ Karlsruhe**.

5c P. Branchini [KLOE Collaboration], *Kloe Results On Kaon Decays And Phi Radiative Decays,* Nucl. Phys. Proc. Suppl. **115**, 145 (2003), **joint INFN-DESY/Karlsruhe**.

6c A. Aloisio *et al.* [KLOE Collaboration], *Searching for $\eta \to \gamma\gamma\gamma$ decay,* contributed paper to International Europhysics Conference on High-Energy Physics (HEP2003, Aachen, Germany, 17-23 Jul 2003) [hep-ex/0307042], **joint INFN-DESY/ Karlsruhe**.

7c M. Moulson [KLOE Collaboration], *Recent results from the KLOE experiment at DAPHNE,* proceedings of 8th Conference on the Intersections of Particle and Nuclear Physics (CIPANP, New York, 19-24 May 2003) [hep-ex/0308023], **joint INFN-DESY/Karlsruhe**.

8c E. Gamiz, J. Prades, J. Bijnens, *Matching the electroweak penguins Q(7) and Q(8),* Invited talk given by J.P. at XIV Rencontres de Blois, Matter Anti-Matter Asymmetry, 18-24 June 2002, and by E.G. at QCD 2002, Montpellier, 2-9 July 2002, to be published in the proceedings, [hep-ph/0209089], **joint Barcelona/Granada-Lund**.

9c E.Oset, D. Jido, J. Palomar, A. Ramos, C. Bennhold and S. Kamalov, *Chiral dynamics in systems with strangeness*, talk in the XVIII European Few Body Conference, Bled, Slovenia, September 2002, Few Body Syst. Suppl. **14**, 263 (2003) [nucl-th/0210077], **joint Valencia-Barcelona**.

10c E. Oset, T. Inoue, M.J. Vicente Vacas, A. Ramos and C. Bennhold, *Chiral unitary approach to hadron spectroscopy,* Talk at the Workshop on partial wave analysis of meson and baryon systems, Pittsburgh, June 2002, Int. J. Mod. Phys. **A18**, 387 (2003) [nucl-th/0209018], **joint Valencia-Barcelona**.

11c P. Mastrolia and E. Remiddi, *Analytic evaluation of Feynman graph integrals,* Nucl. Phys. Proc. Suppl. **116**, 412 (2003) [hep-ph/0211210], **joint INFN/Bologna- DESY/Karlsruhe**.

12c M. Caffo, H. Czyz and E. Remiddi, *Numerical evaluation of master integrals from differential equations,* Nucl. Phys. Proc. Suppl. **116**, 422 (2003) [hep-ph/0211178], **joint INFN/Bologna-Warsaw/Katowice**.

13c G. Venanzoni *et al.* [KLOE Collaboration], *Measurement of hadronic cross section and preliminary results on the pion form factor using the radiative return at DAPHNE,* eConf **C0209101** (2002) WE07 [hep-ex/0210013], **joint INFN-DESY/Karlsruhe**.

14c A. G. Denig *et al.* [the KLOE Collaboration], *Measuring the hadronic cross section via radiative return,* Nucl. Phys. Proc. Suppl. **116**, 243 (2003) [hep-ex/0211024], **joint INFN-DESY/Karlsruhe**.

15c A. Passeri *et al.* [KLOE Collaboration], *Recent results from the KLOE experiment at DAPHNE,* proceedings of 38th Rencontres de Moriond on Electroweak Interactions and Unified Theories (Les Arcs, France, 15-22 Mar 2003) [hep-ex/0305108], **joint INFN-DESY/Karlsruhe**.

16c A. Aloisio *et al.* [KLOE Collaboration], *Determination of* $\sigma(e^+e^- \to \pi^+\pi^-)$ *from radiative processes at DAPHNE,* contributed paper to International Symposium on Lepton and Photon Interactions at High Energies (LP03, Batavia, Illinois, 11-16 Aug 2003) [hep-ex/0307051], **joint INFN-DESY/Karlsruhe**.

17c H. Czyz, J. H. Kühn, G. Rodrigo, *Radiative return at* e^+e^- *factories,* Nucl. Phys. (Proc.Suppl.) **B116**, 249 (2003) [hep-ph/0211186], **joint DESY/Karlsruhe- Warsaw/Katowice**.

18c G. Rodrigo, H. Czyz, J. H. Kühn, *Precision measurement of the hadronic cross-section through the radiative return method,* Nucl. Phys. (Proc.Suppl.) **B123**, 167 (2003) [hep-ph/0210287], **joint DESY/Karlsruhe-Warsaw/Katowice**.

1.2.3 Preprints (p)

1p V. Cirigliano, A. Pich, G. Ecker, H. Neufeld, *Isospin violation in* ε'/ε, [hep-ph/0307030] (Phys. Rev. Lett. in press), **joint Valencia-Vienna**.

2p M. Battaglia *et al.*, *The CKM matrix and the unitarity triangle,* [hep-ph/0304132], **joint INFN-Valencia-Paris-Bern/Zurich-Warsaw**.

3p A. Bramon, G. Garbarino and B.C. Hiesmayr, *Quantum marking and quantum erasure for neutral kaons,* [quant-ph/0306114], **joint Barcelona-Vienna**.

4p A. Bramon, G. Garbarino and B.C. Hiesmayr, *Quantitative duality and neutral kaon interferometry in CPLEAR experiments,* [hep-ph/0307047], **joint Barcelona-Vienna**.

5p G. Colangelo, S. Dürr, R. Sommer, *Finite size effects on* M_π *in QCD from Chiral Perturbation Theory,* [hep-lat/0209110], **joint DESY/Zeuthen-Bern**.

6p T. Hyodo, A. Hosaka, E. Oset, A. Ramos, M. J. Vicente-Vacas, $\Lambda(1405)$ *production in the* $\pi^-p \to K^0\pi\Sigma$ *reaction,* [nucl-th/0307005], **joint Valencia-Barcelona**.

7p A.M. Green and S. Wycech, *On* η-π *mixing close to the* η-*Helium threshold,* [nucl-th/0308057], to appear in Phys. Rev. C, **joint Helsinki-Warsaw**.

8p R. Bonciani, P. Mastrolia and E. Remiddi, *QED vertex form factors at two loops,* [hep-ph/0307295], **joint INFN-DESY/Karlsruhe**.

9p H. Czyz, A. Grzelinska, J. H. Kühn, G. Rodrigo, *The radiative return at* ϕ- *and* B-*factories: FSR at next-to-leading order,* [hep-ph/0308312], **joint DESY/Karlsruhe-Warsaw/Katowice**.

10p K. Kołodziej, F. Jegerlehner, `EE4FGAMMA`: *A program for $e^+e^- \to 4f, 4f\gamma$ with nonzero fermion masses*, [hep-ph/0308014], **joint DESY/Zeuthen-Warsaw/Katowice**.

11p R. M. Godbole, A. Grau, G. Pancheri and A. De Roeck, *Predictions for the gamma gamma total cross-section in the TeV region: An update*, [hep-ph/0303018], **joint INFN-Barcelona**.

12p C. Amsler and N. A. Törnqvist, *Mesons beyond the naive quark model*, submitted for publication in Physics Reports, **joint Helsinki-Bern/Zurich**.

1.2.4 Young Researcher Publications

In the following we list publications by the young researchers financed by the contract, ordered according to the node where they were appointed.

Beatrix Hiesmayr : UAB Universitat Autònoma de Barcelona

- A. Bramon, G. Garbarino, B.C. Hiesmayr, *Quantitative Duality and Neutral Kaon Interferometry in CP LEAR Experiments*, Jul 2003. 10pp. e-Print Archive: hep-ph/0307047

- A. Bramon, G. Garbarino, B. Hiesmayr, *Quantum Marking and Quantum Erasure for Neutral Kaons*, Jun 2003. e-Print Archive: quant-ph/0306114

Bruno Julia-Diaz : UH.DPHY University of Helsinki

- B. Julia-Diaz, A. Valcarce, F. Fernandez, *The $p(d, d')$ reaction and the $\sigma N N^*(1440)$ Coupling Constant* Aug 2003. 8pp. Contributed to 2nd Conference on Nuclear and Particle Physics with CEBAF at Jlab (NAPP 2003), Dubrovnik, Croatia, 26-31 May 2003. e-Print Archive: nucl-th/0308086

2 Part B - Comparison with the Joint program of Work (Annex I of the contract)

2.1 B1. Research Objectives

All the research objectives described in the Contract and reproduced in the previous section, are still relevant and, in our opinion, achievable. In the subsection dedicated to the work plan, more details about the progress of the project, can be found.

2.2 B.2 Research Method

There has been no change in the research method described in our Contract, which is based on the use of *Effective Theories of Colours and Flavours* applied to the study of elementary particle interactions through data collected by experiments in the low and intermediate energy region, like KLOE and DEAR at DAPHNE, WASA, NA48, DIRAC, BaBar, BELLE, CESR-C, FOCUS, SELEX, B-TeV, HERA-B, LHC-B. The theoretical methods used have included

- Chiral Perturbation Theory

- Large N_c- expansion

- Heavy Quark Effective Theory

- Exact Renormalization Group

- QED and Perturbative QCD,

- Quantum Mechanics

2.3 B.3 Work Plan

Breakdown of Tasks

The work plan of the EURIDICE network is structured in a number of tasks, grouped into three main groups. This structure is reproduced in the three tables which follow, where, together with an asterisk (*) to indicate the assigned tasks at the time of the Contract, we have include a $\sqrt{}$ to indicate the present involvement of the groups. From these tables one can see that most groups are actually performing the task as originally planned. Further updates and completions of tasks can be expected as the project moves on.

Table 1: Task Assignments in theoretical developments in Effective Field Theories

Team	Quark masses	ChPT 3 flavours	Isospin breaking effects	Large N_c QCD	N_f/N_c dependence	Lattice QCD and ChPT	HQET and LEET	EFT in Nuclear matter
INFN			★				★√	★
UVEG	★√	★	★√	★√		★	★	★√
UAB		★√		★√	★			
CNRS DR12		★	★	★		★√	★	
CNRS-IN2P3	★	★ √	★	★	★ √		★ √	
DUR	★		★					★
ULUND	★√	★√	★	★√		★√	√	
UHELS	★	★	★	√		√		
DESY Zeuthen	★		★			★√		
UNIBE	★	★	★√	★		√	★	
Vienna		★	★√					
Warsaw		★	★					

Table 2: Task Assignments in theoretical estimates and modelling of precision measurements

Team	CP CPT QM	CKM Matrix	Rare K-decays	Charm and Beauty decays	$(g-2)_\mu$ and α_{QED}	α_s in infrared	glueball spectroscopy
INFN	★√	★√	★√	★√	★√	★√	
UVEG	★√	★√	★	★√	★√		
UAB	★√	★ √	★	★√	√	√	
CNRS DR12	★√	★√	★√	★√	★√		
CNRS-IN2P3	★ √	★ √	★	★ √			
DUR				★√	★	★	★√
ULUND	★√	★√	★	★√			
UHELS				★√			★√
DESY Zeuthen					★√		
UNIBE	★√	★√	★√	★√	★√		
Vienna	★√	★√	★		★		
Warsaw	★√	√	★	★√	★√		★

Table 3: Task Assignments in studies for future or upcoming experiments

Team	Hadronic atoms at DEAR and DIRAC	η, η' at WASA and KLOE	MC and Rad.Corr. for σ_{had} at KLOE and PEPII	τ-Charm factories	Kaon-Nucleon scattering	Hyper nuclei from FINUDA
INFN	★		★		★	★
UVEG				★√	★√	★√
UAB		★		★	★	★√
CNRS DR12	★	★		★		
CNRS-IN2P3	★	★		★		
DUR				★√	★	★√
ULUND	√	★√				
UHELS	★√	★√		★		
DESY Zeuthen			★√			
UNIBE	★√	★			★	
Vienna				★		
Warsaw	★	★	★√	★	★	

Effort of the Participants

This network consists of 1 Coordinator and 11 participants, 9 of which from Member States, 1 from an Associated State and 1 from Switzerland. Some of the teams include researchers belonging to different institutions, as we specify in the following.

1. Istituto Nazionale di Fisica Nucleare [INFN-LNF] established in Italy which includes external team members from Sezione INFN di Roma1, Sezione INFN di Roma3, Sezione INFN di Napoli, Sezione INFN di Bari, Sezione INFN di Perugia, Sezione INFN di Bologna, Sezione INFN di Trieste, Sezione INFN di Torino.

2. University of Valencia [UVEG] established in Spain which includes external team members from University of Madrid

3. Universitat Autonoma de Barcelona [UAB] established in Spain which includes external team members from Universidad de Granada, Universitat de Barcelona, Universitat Politecnica de Catalunya

4. CNRS-CPT Luminy, Marseille [CNRS-DR12] established in France

5. CNRS - Institut National de Physique Nucleaire et de Physique des Particules [CNRS/IN2P3] established in France, which includes external team members from IPN- Orsay, LPT - Orsay, Ecole Polytechnique - Palaiseau, LPNHE - Paris.

6. Universiy of Durham [DUR] established in the United Kingdom which includes external team members from Oxford University, University of Manchester

7. University of Lund [ULUND] established in Sweden which includes external team members from University of Oslo, Norway

8. University of Helsinki [UHELS] established in Finland

9. DESY Zeuthen [DESY Zeuthen] established in Germany which includes external team members from University of Karslruhe

10. University of Bern [UNIBE] established in Switzerland which includes external team members from University of Zurich

11. Universitat Wien [UWIEN.ITP] established in Austria

12. Warsaw University [Warsaw] established in Poland which includes external team members from IPJ (Soltan Institute of Nuclear Studies), Warsaw and University of Silesia, Katowice

The network has two subnodes

- University of Oslo, Norway, as a subcontractor of University of Lund, Sweden

- University of Karslruhe, Germany, as a subcontractor of DESY Zeuthen, Germany

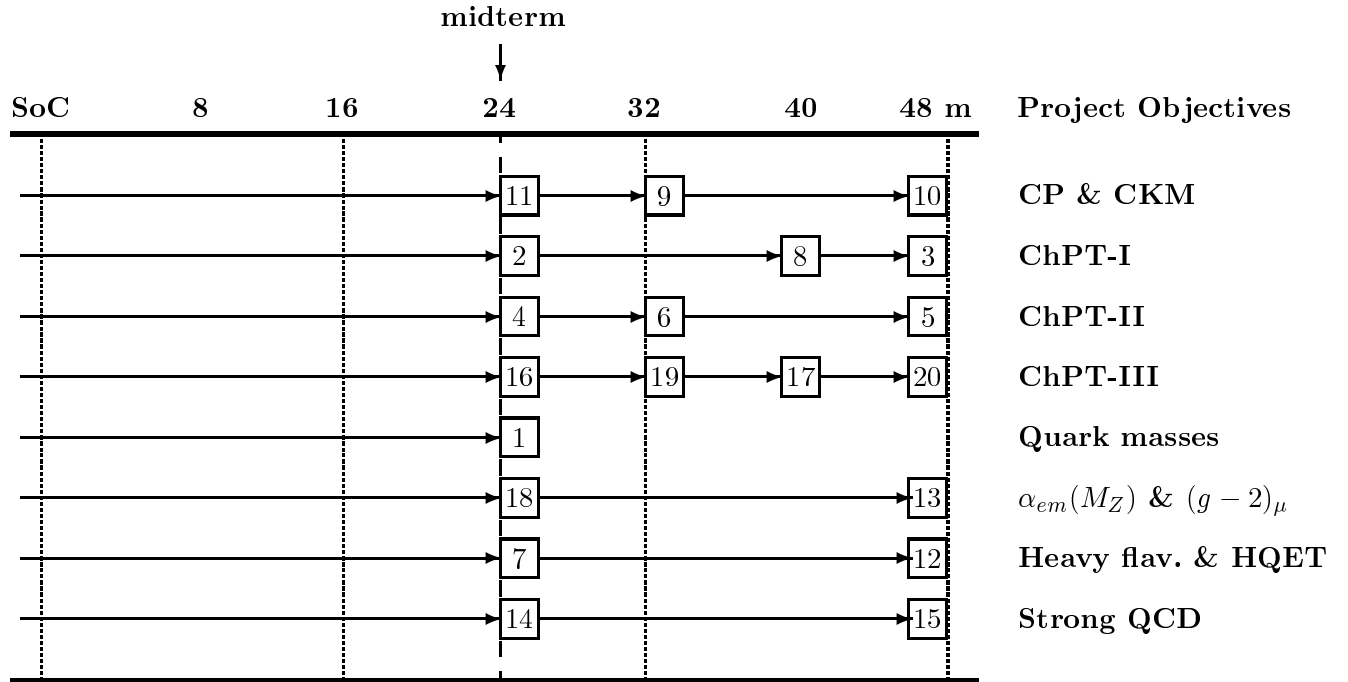Table 4: EURIDICE Research Effort: Column (c) includes also the young researchers financed by the Contract

N.º	Team	Young Researchers to be financed by the contract (person-months) (a) as in the contract, (b) as of 31/08/03		Researchers to be financed from other sources (person-months)/year (c) as in the contract, (d) as of 31/08/03		Researchers likely to contribute to the project (number of individuals) (e) as in the contract, (f) as of 31/08/03	
		(a)	(b)	(c)	(d)	(e)	(f)
1.	INFN	48		155	146	30	24
2.	UVEG	30	6	200	200	19	18
3.	UAB	30		222	222	26	27
4.	CNRS DR12	24		80	84	12	11
5.	CNRS-IN2P3	24		66	66	12	12
6.	DUR	48		60	42	10	7
7.	ULUND	13		53	53	6	6
8.	UHELS	13	3	58	52	8	8
9.	DESY Zeuthen	24		122	119	13	17
10.	UNIBE	24	10	226	259	13	19
11.	Vienna	24		60	48	9	8
12.	Warsaw	0		67	59	11	12
Totals		302	19	1369	1350	169	169

Table 4 illustrates the present involvement of scientists from different nodes in comparison with what was stated in Annex I of the Contract. As one can see, the original involvement is very similar to the present one.

Schedule and Milestones

All the work is proceeding according to the schedule laid out in the Contract. As one can see from the original plan, there are no milestones to be reached until two years after the start of the contract, and, since, so far, no delays are being reported, we expect to reach the milestones in time for the Mid Term Review Meeting. We reproduce in the following the milestone table from the contract.

EURIDICE Schedule and Milestones

midterm

SoC	8	16	24	32	40	48 m	Project Objectives

11	9	10	**CP & CKM**
2	8	3	**ChPT-I**
4	6	5	**ChPT-II**
16	19	17	20	**ChPT-III**
1			**Quark masses**
18	13	$\alpha_{em}(M_Z)$ **&** $(g-2)_\mu$
7	12	**Heavy flav. & HQET**
14	15	**Strong QCD**

Legend: SoC=Start of Contract, m=months

Tasks:

1   Quark masses
2   ChPT with 3 flavours
3   Isospin breaking effects
4   Large-N_c QCD
5   N_f/N_c dependence
6   Lattice QCD and ChPT
7   HQET and LEET
8   EFT in nuclear matter
9   CP, CPT and QM
10 CKM matrix
11 Rare K-decays
12 Charm and Beauty decays
13 $(g-2)_\mu$ and α_{QED}
14 α_s in the infrared region
15 Glueball spectroscopy
16 Hadronic atoms at DEAR and DIRAC
17 η and η' at WASA and KLOE
18 Monte-Carlo methods and radiative corrections for σ_{had} at KLOE and PEPII
19 Kaon-Nucleon scattering
20 Hypernuclei at FINUDA

2.4 B.4 Organization and Management

2.4.1 B.4.1 Coordination and communication strategy

- *Network organization and management :* The network has been organized following the guidelines described in the Work Program. Coordination and communications were based on the Team Committee constituted by the 12 scientists in charge, who exchanged frequent e-mails and telephone calls to discuss and plan both network meetings as well as the training programme. The state of the network could be regularly checked through the network web page, **http://www.lnf.infn.it/theory/rtn/** where announcement of meetings as well as available positions were posted.

- *Decision making :* The process followed along the work program, through the establishment of the Network Executive Committee, consisting of the 12 scientists in charge, implemented by representatives from the two subnodes, i.e. Karlsruhe (DESY-Zeuthen subnode) and Oslo (Lund subnode), by the representative from the Granada team, by the monitor of progress in B-physics, L. Oliver fom the Orsay node, and the Analysis Coordinator of the KLOE experiment, J. Lee Franzini from the LNF-INFN node. Two meetings were held : in the first one, held in Frascati in October 2002, the Executive Committee decided the dates for the call for young researcher training positions and planned for the various meetings and workshops organized by the participants. In the second meeting, held in Orsay in February 2003, the hiring for the year 2003 proposed by each node was approved.

- *Publications and dissemination of information :* The network results have been published in journals, and/or electronic bulletin boards, and/or presented at Conferences. During the first year of operation, the network web page did not follow the individual publication record, but the situation is now improved, with the establishment on the web page of a dedicated space.

- *Presentation at International Conferences :* During the reporting period, network members have participated with presentations to the following International Conferences (details can be found in the individual node contributions at the end of this report) :

  - ⋆ American Physical Society Meeting in Baltimore, USA, April 2003
  - ⋆ Linear Collider School in Ambleside, UK, August 2003
  - ⋆ Tenth International Conference on Hadron Spectroscopy, Aschaffenburg, Germany
  - ⋆ Photon 2003 International Conference on the Structure and Interactions of the Photon, including the 15th International Workshop on Photon-Photon collisions, Frascati, Italy, April 2003
  - ⋆ 10th High Energy Physics International Conference on QCD (Montpellier, 2-9 July 2003).

- *Field Trips :* The Coordinator visited the Massachussetts Institute of Technology, to discuss with A. Bernstein about the organization of the future Chiral Dynamics Workshops, where many of the network results are traditionally reported. Discussions with other MIT theorists were also part of the trip.

2.4.2 B.4.2 Network meetings

As part of the training and networking program, three types of meetings were organized during the first year of operation, namely

★ Collaboration meetings,

★ Topical workshops

★ LNF Spring School.

For all these meetings, we reproduce the poster, the list of participants and the scientific program at the end of this report. Further details can be found in the reports by the individual nodes where such meetings were organized and/or in the network web page. The list of such meetings follows :

- Start-off Collaboration Meeting, Frascati, 18-20 October 2002.

  Organized by G. Pancheri, attended by about 50 participants from the network. No external experts were invited.

- Second Collaboration Meeting, Orsay, 6-8 February 2003.

  Organized by J. Stern and attended by about 70 scientists, with external experts invited.

- LNF Spring School Bruno Touschek, Frascati May 19-23rd 2003.

  Organized by G. Pancheri, attended by approximately 50 students, including some young researchers of the network already hired or to be soon hired, and young researcher from another RTN network, ESOP, which traditionally has held joint sessions with EURIDICE.

- Workshop on Chiral Dynamics of Hadrons and Hadrons in a Medium, June 26-28th, 2003, Valencia, Spain.

  Organized by E. Oset from the Valencia node jointly with A. Ramos of Barcelona node, and attended by about 64 people with external experts.

2.4.3 B.4.3 Networking

As one can see from the list of joint publications, a large number of scientific exchanges took place among network participants during the first year of operation. In many cases, there have been practically daily e-discussions among nodes, as it was the case between Vienna (G. Ecker) and Valencia (Toni Pich and Vincenzo Cirigliano) all year around. Most joint work being based on pre-existing collaborations, e-mail was the principal mean of exchange. Secondments and visits were also part of networking, as indicated in the accompanying table (topics of the corresponding scientific exchanges are written cursive) and described in details in the individual node reports.

From/to	Team 1	Team 2	Team 3	Team 4	Team 5	Team 6
Team 1					P. Colangelo G. Narduli G. Pancheri	G. Isidori
Team 2	E. Oset V. Cirigliano M. Döring E. Palomar			L. Roca		
Team 3	D. Espriu J. Matias	J. Soto		O. Cata (2×)		
Team 4			E. d Rafael w. S. Peris *Large-N_C*		G. Giusti E. de Rafael D. Greynat S. Friot M. Knecht	
Team 5	T.N. Pham *B-decays and CP asymmetry* with P. Colangelo, G. Narduli					J. Hirn with M. Pennington
Team 6	M.Pennington				M.Pennington	
Team 7	J. Bijnens E. Lipartia F. Persson Meeting				J. Bijnens P. Dhonte J.O. Eeg E. Lipartia	
Team 8	visits*					
Team 9	F.Jegerlehner with KLOE 2 talks J.H. Kühn				R. Sommer S. Müller W. Kluge Coll. Meeting	
Team 10	visits**				visits***	
Team 11	R.Unterdorfer scientific exchanges	G. Ecker *Four pions in e^+e^-* H. Neufeld				
Team 12	H. Czyż M. Misiak L. Lukaszuk M. Krawczyk *Aspects of partonic content of the photon* E. Nowak	S. Wycech Seminar *η-π mixing*	S. Wycech *K mesons* with A. Ramos			

From/to	Team 7	Team 8	Team 9	Team 10	Team 11	Team12
Team 1		G. Pancheri				
Team 2					V.Cirigliano	
Team 3	J. Prades scientific exchanges				B.Hiesmayr	F. Cornet *parton densities in the photon* with M. Krawczyk
Team 4						
Team 5						
Team 6						
Team 7						
Team 8						
Team 9						
Team 10			G. Colangelo *Experimental determination of the chiral condensate* H. Leutwyler *Experimental evidence for the quark condensate*			
Team 11						
Team 12		S. Wycech *η-He bound states, η-π mixing*	M. Czakon *Two-loop Electroweak Corrections to Δr* K. Kolodziej H. Czyz A. Grzelinska *PHOKHARA MC event generator(2$\times$)* E. Nowak	M. Misiak $B \to X_s l^+ l^-$ with D. Wyler and E. Lunghi $B \to X_s \gamma$ with C. Greub 2 seminars		

* M. Sainio, T. Lähde, P. Piirola (Collaboration Meeting).

** J. Gasser, Ch. Greub, I. Scimemi, M. Verbeni, J. Schweizer (Collaboration Meeting).

*** J. Gasser, Ch. Greub, B. Kubis, J. Schweizer (Collaboration Meeting).

2.5   B.5 Training

2.5.1   B.5.1 Measures taken to publicize vacant positions

Vacant positions were advertized through the Cordis page, through the network page, through electronic distribution of the advertisement to the CERN theoretical group mailing list and to individual node e-mail lists. Not all nodes advertised the available positions during the first year of operation.

2.5.2   B.5.2 Progress in recruitment of young reseachers

The training plan is proceeding well. During this first year, only three nodes have hired young researchers, but already a majority of positions is committed to young researchers who have been offered positions for the year 2003 and 2004, and who accepted them. In the accompanying Table 5, we show the original training plan together with the hiring at the end of the first year and the presently committed positions, where pm indicates the length of the contract in person-months.

Comment on the state of training

We notice that 65 % of all the positions available have already been committed. To fully see the present state of training, we list the situation in each node, indicating for each young researcher :

- Name

- Type of training

- Date of birth

- Nationality

- Start of contract

- Duration of Contract

1. INFN-LNF : 48 months in contract-33 months committed
   ****
   Rene Unterdorfer
   Pre-doc (PhD thesis with G. Ecker, scientist in charge of the Vienna node)
   February 19th, 1976
   Austrian
   September 1st 2003
   9 months

****

Christopher Smith

Post-doc

April 8th, 1974

Belgian and French

October 1st 2003

24 months

2. Universidad de Valencia : 30 months in contract

3. Universitat Autonoma de Barcelona : 30 months in contract-30 months committed
****

Name: Beatrix C. Hiesmayr.

Post-doc.

Birthdate: Jan. 27th, 1975.

Austrian.

Feb. 1st, 2003.

6 months.
****

Ignazio Scimemi

Post-doc

Birthdate 9/9/69

Italian

1 Oct 2003

12 months (extension to other 12 months possible)

Note: Of the initial 12 months only 6 are paid by EURIDICE, the rest are paid from local sources
****

Michela Verbeni at U. of Granada

Post-doc

Birthdate: June 16th, 1970

Italian

October 1st, 2003

Duration: 18 months with possible extension to 24 months with

University funding

4. Marseille : 24 months in contract-24 months committed

   Sylvia Necco

   post-doc

   date of birth : 26 May 1974

   Italian

   Start of appointment : Oct. 1st 2003

   24 months

5. Orsay : 24 months in contract

6. U. of Durham : 48 months in contract-14 months committed

   Johannes Hirn

   Student

   October 3rd, 1977

   one year from October 1st, 2003

   ****

   K. Benhaddou

   Student

   November 20th, 1973

   two month from October 1st, 2003

7. U. of Lund : 13 months in contract-13 months committed

   Timo Lähde

   Post-doc

   July 30, 1977

   Finnish

   October 1st 2003

   24 months

8. U. of Helsinki : 13 months in contract-13 months committed

   Bruno Julia-Diaz

   Post-doc

   September 13th, 1975

   Spanish

   June 1st 2003

   13 month (24 months)

   ****

   For the duration, the number (13 months) is the one from contract. Probably the Helsinki node will actually use the EU money in 14 months and then use the Academy

of Finland grant for the remaining 10 months (the 24 months in the parentheses refers to the expected total stay in Helsinki)

****

9. DESY-Zeuthen : 24 months in contract-24 months committed

   Michal Czakon

   Post-doc

   April 11th, 1974

   Polish

   October 1st, 2003

   24 month

10. U. of Bern : 24 months in contract-24 months committed

    Bastian Kubis

    Post-doc

    February 6th, 1974

    German

    November 1st 2002

    24 months

11. U. of Vienna : 24 months in contract-24 months committed

    Roland Kaiser

    Post-doc

    Feb. 17, 1972

    Swiss

    Oct. 1, 2003

    24 months

2.5.3   B.5.3 Integration into the research program

As mentioned, during this period only a small fraction of the proposed training took place, with only three young researchers being hired, by the Barcelona, Helsinki and the Bern node, respectively. All the young researchers so far have been fully integrated in the research programme, some of them have already published their result in the form of electronic preprints and the relative papers have been submitted for publication in the international journals. In particular for the Barcelona node, a six month Post-Doc contract has been given to Dr. Beatrix C. Hiesmayr from Vienna University. The subject of her recent PhD thesis was close to the interests of the node and her integration offered no difficulties and produced the expected results: three publications on Quantum Mechanics for neutral kaons with a clear multidisciplinary content. Dr. Hiesmayr training included presentations at conferences and her first contact with Latin languages. In the Helsinki node, Dr. Bruno Julia-Diaz joined the group starting from June 2nd, 2003, with an expected stay of 24 months, 13 of which will be covered by the EU grant.

2.5.4   B.5.4 Training measures

The measures undertaken in the training program concerned both the individual training and the common training. As described before, the three young researchers already hired were immediately integrated into the existing research teams and started collaborating with members of the teams. Because of their joining the teams rather late in the first period, it had not been possible to make them to participate to the two Collaboration Meetings or the topical workshops. Such participation is expected to take place in the next period.

2.5.5   B.5.5 Promotion of equal opportunities.

The network has a good proportion of women in leading positions, since 4 out of the 17 members of the Executive Committee are women, namely the Coordinator, the scientist in charge of the Warsaw node, the scientist in charge of the Granada team and the KLOE experiment analysis coordinator. This increases the visibility of women in the field. At the national level, the Coordinator has presented talks in various places on the position of women in Physics, and has presently requested the Italian Physical Society to start a nationwide study of the presence of women in all fields of physics. During the Photon 2003, the International Conference on Photon Structure held in Frascati, special care was placed on the visibility of women scientists, as two well known women scientist were invited to give the Opening Address and the Summary talk, respectively (for details see the Conference web site http://www.lnf.infn.it/conference/photon03/). In order to increase participation of women, special activities have taken place in the Helsinki node, which has been active in the IUPAP International Conference of Women in Physics. A special university wide Colloquium on Women in Physics was held in University of Helsinki by this Coordinator. It may be noticed that one out of the three young researchers hired by the network during the first year of operation and two of the ten newly appointed young researchers are women.

2.5.6   B.5.6 Multidisciplinarity

This is a network in theoretical particle physics with phenomenological applications. From this point of view, multidisciplinarity is hard to be included. We can however notice that the close collaboration between experimentalists and theorists in our network already allows for a large and partly unique exchange between different fields in the same discipline. In addition, the training in the field of Quantum Mechanics, as in the case of the Barcelona node, involves a certain degree of interdisciplinarity.

2.6   B.6 Difficulties

The network has not encountered any substantial difficulty, except for some small administrative delays due to transfer of funds between the Lund node and the Oslo subnode, which however have then been solved. The collaborations are well established and the addition of the new team from Warsaw is also based on pre-existing exchanges, so that no difficulties need be reported from the point of view of integration of the teams.

Table 5: Training

Participant	Contract deliverable to YR to be financed by the contract (person-months)			YR financed by the contract so far and in next period (person-months)			Committed to start or continue after 01/09/2003 (person-months)
	(a)	(b)	(a+b)	(c)	(d)	(c+d)	
1. INFN-LNF	24	24	48				R. Unterdorfer 9 C. Smith 24
2. UVEG		30	30				
3. UAB		30	30		B. Hiesmayr 6	6	I. Scimemi 6 M. Verbeni 18
4. CNRS-DR12		24	24				S. Necco 24
5. CNRS/IN2P3		24	24				
6. DUR	24	24	48				J. Hirn 12 K. Benhaddou 2
7. ULUND		13	13				T. Lähde 13
8. UHELS		13	13		B. Julia-Diaz 3	3	B. Julia-Diaz 10
9. DESY Zeuthen		24	24				M. Czakon 24
10. UNIBE		24	24		B.Kubis 10	10	B. Kubis 14
11. UWIEN.ITP		24	24				R. Kaiser 24
TOTAL	48	254	302		19	19	180

3 ANNEX : Reports from the Individual Nodes

In this Annex we add individual reports from the nodes. Albeit such individual reports are not requested, they may be useful to check the list of single institute publications, explanation of expenses, description of scientists participating to the activities, etc., all of which is summarized in the main body of this report. The individual node reports also contain the detailed information about various institutes participating to the work of a node, as mentioned in the main text.

The nodes are listed according to the following structure :

1. INFN: Coordinator from INFN Laboratori Nazionali di Frascati (LNF)
2. UVEG: Participant from University of Valencia
3. UAB: Participant from Universitat Autònoma de Barcelona
4. CNRS DR12: Participant from CNRS-CPT Luminy, Marseille
5. CNRS-IN2P3: Participant from Orsay, Paris
6. DUR: Participant from University of Durham
7. ULUND: Participant from Lund University
8. UHELS: Participant from University of Helsinki
9. DESY Zeuthen: Participant from DESY Zeuthen
10. UNIBE: Participant from University of Bern
11. Vienna: Participant from Universität Wien
12. Warsaw: Participant from Warsaw University (Poland)

3.1 INFN-LNF

Participant Number 1: INFN-LNF

LNF: **Giulia Pancheri** (100%), G. Isidori (70%), J. Lee-Franzini (50%), E. Nardi (30%); SCIENTIFIC
Bari: P. Colangelo (90%), F. De Fazio (90%); Bologna: M. Caffo (60%), E. Remiddi (40%); STAFF
Naples: G. D'Ambrosio (100%); Perugia: O. Panella (30%), Y. Srivastava (30%), N. Fabiano
(100% Post-doc), M. Cannoni, S. Pacetti (50% Ph.D. Sts.); Rome1: P. Franzini (50%);
Rome-III: A. Farilla (50%), A. Ferrari (50% Post-doc), F. Nguyen (100% Ph.D. St.); Trieste:
F. Benatti (10%), R. Floreanini (10%), N. Paver (40%); Torino: W. Alberico (30%), A. De
Pace (20%), A. Molinari (20%)   Total: 24 researchers

Scientific Highlights

- *CP violation and rare decays*
  LNF and Napoli groups have presented a new analysis of the rare decay $K_L \to \pi^0 e^+ e^-$
  which demonstrates that this mode can be used in the future to perform precision
  studies of short-distance dynamics in $\Delta S = 1$ FCNC transitions. The LNF group,
  in collaboration with the Bern/Zurich node, has obtained significant results toward a
  complete NNLL analysis of $B \to X_s \ell^+ \ell^-$.

- $(g-2)_\mu$ *and multi-loop calculations.*
  The Bologna group, in collaboration with the Karlsruhe node, has obtained several
  new results about precise or analytic evaluations of multi-loop Feynman graphs mainly
  through Differential Equations (DE):
  - Multi-scale: 2-loop sunrise and other self-mass graphs relevant for EW model.
  - Fully analytic calculations: at special values $p^2 = 0, \infty$, threshold, pseudo-thresholds.
  - Few-scale: up to 4-loop, static quantities ($g-2$, vac-pol); 1-scale sunrise and tadpoles.
  - Numeric calculations: direct numerical solution of DE through 4-th order Runge-
  Kutta method.

- *Heavy-quark systems and scalar mesons.*
  The researchers of the Bari group have performed new studies on the following sub-
  jects: i) structure of $f_0(980)$; ii) analysis and interpretation of the particle $D_{sJ}(2317)$,
  recently observed by BABAR, BELLE and CLEO Collaborations; iii) study of the
  validity of factorization in nonleptonic B decays.

- *Non-standard time evolution of meson-antimeson systems.*
  The Trieste group has studied the dissipative dynamics describing he propagation of
  neutral kaons in randomly fluctuating media, proposing possible experimental tests.

- *Strong QCD limit*
  The LNF and Perugia groups, in collaboration with the Granada team from Barcelona
  node, has continued its investigation into properties of total cross-sections which de-
  pend on the soft-gluon resummation and singular α_S formalism developed in earlier
  work.

- *Experimental progress of KLOE.*
  In the last 12 months the KLOE collaboration has performed several new measure-
  ments of K decays and low-energy hadronic cross sections. The two most significant

results are:
- preliminary measurements of $K_{L,S} \to \pi \ell \nu$ branching ratios (and the related extraction of the CKM element $|V_{us}|$);
- preliminary measurements of the pion form factor using the radiative return method (and the related evaluation of the hadronic $(g-2)_\mu$).
Several members of the INFN node are presently involved in the theoretical analysis of these new results.

Organization of Meetings and other net-wide Activities

The Frascati group publishes the network web page and has organized two meetings : the start-off Collaboration meeting in October 2002 and the LNF Spring School in May 2003.

Travel Expenditures

G. Pancheri, travel to Orsay, for Collaboration Meeting, 5/02/03-9/02/03
G. Isidori, travel to Durham, for the 2nd CKM Workshop, 31/03/03-10/04/03

Publications

1. F. Benatti, R. Floreanini, and R. Romano, *Neutral kaons in random media,* hep-ph/0309257, to appear in Phys. Rev. D.

2. G. Buchalla, G. D'Ambrosio and G. Isidori, *Extracting short-distance physics from $K_{L,S} \to \pi^0 e^+ e^-$ decays,* Nucl. Phys. B **672** (2003) 387 [hep-ph/0308008].

3. P. Colangelo and F. De Fazio, *Understanding $D_{sJ}(2317)$,* Phys. Lett. B **570** (2003) 180 [hep-ph/0305140].

4. P. Colangelo and F. De Fazio, *Coupling $g_{f_0 K^+ K^-}$ and the structure of $f_0(980)$,* Phys. Lett. B **559** (2003) 49 [hep-ph/0301267].

5. G. D'Ambrosio, *Recent developments in rare kaon decays,* Mod. Phys. Lett. A **18** (2003) 1273 [hep-ph/0305249].

6. G. D'Ambrosio, G. F. Giudice and M. Raidal, *Soft leptogenesis,* Phys. Lett. B **575** (2003) 75 [hep-ph/0308031].

7. F. De Fazio, *Non factorizable effects in nonleptonic B decays to charmonium,* eConf **C0304052** (2003) WG404 [hep-ph/0306276].

8. N. Fabiano and G. Pancheri, *Two photons width of heavy pseudoscalar mesons,* hep-ph/0210279.

9. G. Isidori, *Summary and overview of working group VI: V_{us} and V_{ud},* eConf **C0304052** (2003) WG601.

10. G. Isidori, *K → πνν̄ decays and CKM fits,* eConf **C0304052** (2003) WG304 [hep-ph/0307014].

11. G. Isidori, *Kaon decays and the flavour problem,* hep-ph/0301159.

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16. M. Caffo, H. Czyz and E. Remiddi, *Numerical evaluation of the general massive 2-loop self-mass master integrals from differential equations,* Nucl. Instrum. Meth. **A502**, 613 (2003) [hep-ph/0211171].

17. P. Mastrolia and E. Remiddi, *The analytic value of a 3-loop sunrise graph in a particular kinematical configuration,* Nucl. Phys. **B657**, 397 (2003) [hep-ph/0211451].

18. R. Bonciani, P. Mastrolia and E. Remiddi, *Vertex diagrams for the QED form factors at the 2-loop level,* Nucl. Phys. **B661**, 289 (2003) [hep-ph/0301170].

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21. A. Aloisio *et al.* [KLOE Collaboration], *Measurement of the branching ratio for the decay $K^\pm → \pi^\pm\pi^0\pi^0$ with the KLOE detector,* contributed paper to International Symposium on Lepton and Photon Interactions at High Energies (LP03, Batavia, Illinois, 11-16 Aug 2003) [hep-ex/0307054].

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26. M. Moulson [KLOE Collaboration], *Recent results from the KLOE experiment at DAPHNE,* proceedings of 8th Conference on the Intersections of Particle and Nuclear Physics (CIPANP, New York, 19-24 May 2003) [hep-ex/0308023].

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29. G. Venanzoni *et al.* [KLOE Collaboration], *Measurement of hadronic cross section and preliminary results on the pion form factor using the radiative return at DAPHNE,* eConf **C0209101** (2002) WE07 [hep-ex/0210013].

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32. A. Aloisio *et al.* [KLOE Collaboration], *Determination of* $\sigma(e^+ e^- \to \pi^+ \pi^-)$ *from radiative processes at DAPHNE,* contributed paper to International Symposium on Lepton and Photon Interactions at High Energies (LP03, Batavia, Illinois, 11-16 Aug 2003) [hep-ex/0307051].

33. M. Battaglia *et al.*, *The CKM matrix and the unitarity triangle,* [hep-ph/0304132].

34. R. Bonciani, P. Mastrolia and E. Remiddi, *QED vertex form factors at two loops,* [hep-ph/0307295].

35. R. M. Godbole, A. Grau, G. Pancheri and A. De Roeck, *Predictions for the gamma gamma total cross-section in the TeV region: An update,* [hep-ph/0303018].

3.2 University of Valencia

Participant Number 2 : UVEG University of Valencia

Antonio Pich (60%), V. Giménez (50%), P. Hernández (50%), E. Oset (100%), J. Portolés (100%), M. Vicente (100%), J. R. Peláez (Univ. Madrid, 100%)
M. Eidemüller, T. Inoue, D. Jido, J. A. Oller, I. Scimemi (Post-docs, 100%),
D. Cabrera, J. C. Nacher, E. Palomar, L. Roca, P. Ruiz, J. J. Sanz (Ph.D. Students, 100%)

Scientific Staff

Total: 18 researchers (average 92%) $\equiv$ 200 p-m/y

Scientific Highlights

The main goals achieved by the research team in the Valencia node can be summarized as follows :

- New determination of the mass of the strange quark (m_s) and the CKM matrix element $|V_{us}|$ from hadronic tau decays.

- New analysis of the spectrum of scalar resonances within the large–N_C expansion and chiral symmetry.

- Evaluation of the isospin breaking corrections to $K \to \pi\pi$ amplitudes at NLO and their impact on the CP–direct observable ε'/ε.

- Phenomenological study of the $\langle VVP \rangle$ Green's function within the Resonance Chiral Theory.

- Analysis of the vector form factor of the pion at next–to–leading order in the $1/N_C$ expansion.

- Study of the matrix elements of $\Delta I = 3/2$ transitions in $K \to \pi\pi$ within lattice QCD.

- Study of the finite size scaling of vector and axial current correlators.

- Analysis of the dynamical generation of baryonic resonances using unitary extensions of chiral perturbation theory.

- New analysis of chiral meson dynamics in nuclear matter.

- Study of scattering poles within fully unitarized ChPT and their behavior with temperature and in the large-N_c limit.

Research Objectives

Further research by the Valencia node network team involve the development of several of the present achievements and of new goals within the original project of the network. Several of these lines of research involve colleagues of other nodes. We summarize them :

- Study of three–point Green's functions of QCD currents within the Resonance Effective Theory of QCD with two main purposes : a) the phenomenology of processes at $E \lesssim 2\,\mathrm{GeV}$ and b) the construction of the effective theory of QCD in the resonance energy region.

- Analysis of semileptonic decays of charmed mesons through an Effective Theory of QCD in the relevant energy region : $D \to P\ell\nu_\ell$ and $D \to V\ell\nu_\ell$.

- Evaluation and study of the scalar form factor at next–to–leading order in the expansion of large–N_C.

- Construction of the vector–vector currents correlator in the resonance energy region aiming to obtain a consistent parameterization of the inclusive hadronic cross–section in the region $2m_\pi \lesssim E \lesssim 2\,\mathrm{GeV}$.

- Evaluation of the observables in the hadronic decays of the lepton tau into three pseudoscalars, $\tau \to PPP\,\nu_\tau$, in the Resonance Effective Theory of QCD and their comparison with the experimental results.

- Study of the dependence of the asymptotic behaviour of QCD form factors in the number of particles in the final state.

- Precise determination of the πN scattering lengths from $\pi^- p$ and $\pi^- deuteron$ data.

- Decays of J/ψ with two final mesons.

- Studies on possible $K\pi N$ bound states or resonances.

- Renormalization of the κ properties in nuclei.

- Photoproduction of the Θ^+ and $\Lambda(1405)$ resonances.

- Dynamical generation of meson and baryon resonances and their properties.

- Critical analysis of π-π scattering descriptions, relating high and low energy.

- Description of chiral phase transition from ChPT at finite temperature and barionic density.

Networking

- The Valencia group has organized this year a Workshop on the topic
  "Chiral Dynamics of Hadrons and Hadrons in a Medium"
  Valencia (Spain), June 26-28, 2003
  with 64 participants from Canada (McGill), France (Lyon), Germany (Darmstadt, Giessen, Heidelberg, Munich, Regensburg, Tbingen), Hungary (Budapest) Italy (Rome III, Trento, Trieste), Japan (Kyoto, Nara, Osaka, Tokyo), Poland (Cracow, Warsaw), Spain (Barcelona, Granada, Madrid, Murcia, Salamanca, Valencia), Switzerland (CERN) and USA (Idaho, Ohio, UCLA, Virginia).

- Eulogio Oset and Vincenzo Cirigliano visited First Euridice Collaboration Meeting (Frascati, 18-20 October 2002).

- Luis Roca visited Second Euridice Collaboration Meeting (Orsay, 6-8 February 2003).

- Michael Dring and Juan E. Palomar visited VIII Frascati Spring School (Frascati, 18-26 May 2003).

- Helmut Neufeld visited Valencia (2 weeks in April 2003).

- Vincenzo Cirigliano visited Wien (2 weeks in June 2003).

Other Conferences

Antonio Pich, Jorge Portols, J.J. Sanz participated in the 10th High Energy Physics International Conference on QCD (Montpellier, 2-9 July 2003).

Joint Publications

Valencia-Barcelona-Granada:

- E. Gamiz, M. Jamin, A. Pich, J. Prades, F. Schwab, "Determination of m_s and $|V_{us}|$ from hadronic tau decays", JHEP 0301 (2003) 060.

- E. Oset, D. Jido, J. Palomar, A. Ramos, C. Bennhold, S. Kamalov, "Chiral dynamics in systems with strangeness", Few Body Syst. Suppl. **14** (2003) 263.

- D. Jido, J.A. Oller, E. Oset, A. Ramos, U.G. Meissner, "Chiral dynamics of the two $\Lambda(1405)$ states", Nucl. Phys. **A725** (2003) 181.

- T. Hyodo, A. Hosaka, E. Oset, A. Ramos, M.J. Vicente-Vacas, "$\Lambda(1405)$ production in the $\pi^- p \to K^0 \pi \Sigma$ reaction", nucl-th/0307005.

Valencia-Marseille (France):

- P.H. Damgaard, P. Hernández, K. Jansen, M. Laine, L. Lellouch, "Finite size scaling of vector and axial current correlators", Nucl. Phys. **B656** (2003) 226.

- P.H. Damgaard, P. Hernández, K. Jansen, M. Laine, L. Lellouch, "Vector and axial–vector propagators inthe ϵ–regime of QCD", hep-lat/0309015.

Valencia-Roma (Italy):

- V. Giménez, L. Giusti, S. Guerriero, V. Lubicz, G. Martinelli, S. Petrarca, J. Reyes, B. Taglienti, E. Trevigne, "Non–perturbative renormalization in coordinate space", hep-lat/0309150.

- Ph. Boucaud, V. Giménez, C.J.D. Lin, V. Lubicz, G. Martinelli, M. Papinutto, C.T. Sachrajda, "Matrix elements of $\Delta I = 3/2$ $K \to \pi\pi$ decays", hep-lat/0309128.

Valencia-Wien (Austria):

– V. Cirigliano, G. Ecker, H. Neufeld, A. Pich, "Meson resonances, large N_C and chiral symmetry", JHEP 0306 (2003) 012.

– V. Cirigliano, A. Pich, G. Ecker, H. Neufeld, "Isospin violation in ε'/ε", hep-ph/ 0307030 (Phys. Rev. Lett. in press).

3.3 Universitat Autònoma de Barcelona

> Participant Number 3 : UAB Universitat Autònoma de Barcelona

UAB: **Albert Bramon** (100%), Ll. Ametller (50%), E. Bagan (50%), J. Matias (50%), S. Peris (100%), B. Hiesmayr (50%), O. Catà (Ph.D. Student, 100%)
UB: D. Espriu (50%), J. I. Latorre (50%), A. Ramos (75%), J. Soto (75%), J. Taron (50%), G. Garbarino (Post-doc, 75%), A. Parreno (Post-doc, 75%), D. Eiras, J. Manzano, L. Tolós (Ph.D. Students, 100%)
UGr, subcontractor: Inés Grau (100%), J. E. Amaro (50%), F. Cornet (50%), C. Garcia Recio (50%), J. I. Illana (50%), J. M. Nieves (50%), J. Prades (100%), E. Ruiz Arriola (50%), L. L. Salcedo (50%), E. Gámiz (Ph.D. Student, 100%)

SCIENTIFIC
STAFF

Total: 27 researchers ≡ 228 p-m/y

Scientific Highlights

- Concerning CP–violating asymmetries, a first update on the predictions for the slope and decay rates of K to 3pi is presented in the joint publication ref. [8] The electroweak penguins Q-7 and Q-8 are studied in ref. [12]

- Studies on the muon (g-2) are of great interest at present. The electroweak hadronic contribution is reconsidered in ref [5]

- Hypernuclei studies and $\Lambda(1405)$ production are central issues in K–Nucleon interactions. Refs. [1, 2] contain valuable progress in this field.

- Quantum Mechanics studies for the neutral kaon system have lead to intereting results: kaons offer excellent opportunities for testing new quantum information concepts such as 'quantum erasure', 'which-way information'...

Networking

- D. Espriu visited Universita' di Napoli to continue collaboration with G. D'Ambrosio for one week (Feb 03).

- J. Soto started there a collaboration with J.A. Oller (U. Murcia)

- E. de Rafael (Marseille) visited S. Peris to continue collaboration and give a course on large-N_C QCD (May 2003)

- O. Cata' visited CPT Marseille twice (October 2002 and September 2003)

- J. Matias visited G. Isidori (Frascati) to start a collaboration (January 2003)

- B. Hiesmayr worked at Vienna with R. Bertlmann in April 2003.

Work plan

As specified in the 3 tables of the contract the Barcelona node has contributed to the following research tasks: ChPT with 3 flavours, Large-N_C, Quantum Mechanics, Charm and Beauty decays and Hypernuclei.

Organisation

Results are presented in scientific workshops and/or published in refereed international journals. Members of the node have assisted at meetings held at Stockholm, Paris, Rome, Montpellier, Madrid and Salamanca among others. Most of the listed joint publications have required research stays in other nodes. We received visitors from Marseille, Valencia and the Polish nodes and people from Barcelona node visited Paris, Rome, Turin, Marseille, Valencia and Warsaw.

Training

Vacant positions were publicised in several web sites and around twenty applications were examined.

A first six month Post-Doc contract has been given to Dr. Beatrix C. Hiesmayr from Vienna University. The subject of her recent PhD thesis was close to the interests of our node and so her integration offered no difficulties and produced the expected results: three publications on Quantum Mechanics for neutral kaons with a clear multidisciplinary content. Dr. Hiesmayr training included presentation of conferences and her first contact with latin languages.

Two candidates for the remaining months of contract have already been selected. Both have accepted the offer and are expected to start working at Barcelona and Granada Universities this Fall 2003.

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[2] D. Jido, J.A. Oller, E. Oset, A. Ramos and U.-G. Meissner, "Chiral Dynamics of the Two $\Lambda(1405)$ States" nucl-th/0303062, Nucl.Phys. A725 (2003) 181-200.

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[5] Electroweak hadronic contributions to the muon (g-2). By Marc Knecht, Santiago Peris, Michel Perrottet, Eduardo De Rafael. JHEP 0211:003,2002. [hep-ph/0205102].

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[7] Hadronic cross-sections in two photon processes at a future linear collider by R.M. Godbole, A. De Roeck, A. Grau and G. Pancheri, JHEP 06 (2003) 061

[8] CP violating asymmetries in K+ to 3 pi in the standard model. By Elvira Gamiz, Joaquim Prades, Ignazio Scimemi. [hep-ph/0305164] BUTP-2003-11 (May 2003).

[9] QCD short distance constraints and hadronic approximations. By Johan Bijnens, Elvira Gamiz, Edisher Lipartia, Joaquim Prades. JHEP 0304:055,2003. [hep-ph/0304222].

[10] Determination of m(s) and —V(us)— from hadronic tau decays. By E. Gamiz, M. Jamin, A. Pich, J. Prades, F. Schwab. JHEP 0301:060,2003. [hep-ph/0212230].

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[14] E. Oset, T. Inoue, M.J. Vicente Vacas, A. Ramos and C. Bennhold, "Chiral unitary approach to hadron spectroscopy". Talk at the Workshop on partial wave analysis of meson and baryon systems, Pittsburgh, June 2002, nucl-th/0209018, Int.J.Mod.Phys. A18 (2003) 387-396.

3.4 CNRS-CPT Marseille

Participant Number 4 : CNRS-CPT Marseille, Luminy

Marc Knecht (6 m/y, 50%), J. Charles (6 m/y, 50%), P. Chiappetta (2 m/y, 17%), L. Giusti (3 m/y, 25%), L. Lellouch (6 m/y, 50%), M. Perrottet (6 m/y, 50%), E. de Rafael (6 m/y, 50%)

SCIENTIFIC STAFF

35 pm/y

C. Hölbling (9 m/y, 75%, Post Doc)

9 pm/y

V. Cuplov (10 m/y, 85%), D. Greynat (10 m/y, 85%), S. Friot (10 m/y, 85%), N. Garron (10 m/y, 85%) (PhD Students)

40 pm/y

Tot. 84 pm/y

Scientific Highlights

The main activities of the CPT team concern several non-perturbative aspects of the Standard Model at low energies in the sector of light quarks as well as heavy quarks.

New results were obtained in [1] for the matrix elements of the Q_6 and Q_4 penguin operators, evaluated in a large-Nc approach which incorporates important $\mathcal{O}(N_c^2 \frac{n_f}{N_c})$ unfactorized contributions. The approach shows analytic matching between short- and long-distance scale dependences within dimensional renormalization schemes, such as $\overline{MS}$. Numerically, there is a large positive contribution to the $\Delta I = 1/2$ matrix element of Q_6 and hence to the direct CP-violation parameter ϵ'/ϵ.

PENGUIN OPERATORS

It has been shown [2] that the introduction of a radial excitation of the D or D^* mesons allows to reproduce the large experimental value of the $g_{D^*D\pi}$ constant from light cone QCD sum rules, while at the same time improving the stability of the sum rule when varying the Borel parameter.

$g_{D^*D\pi}$ COUPLING

Within the framework of ChPT with virtual photons and leptons, an updated analysis of the pionic β decay was performed [3], including all electromagnetic contributions of order $\mathcal{O}(e^2p^2)$. The extraction of the CKM matrix element $|V_{ud}|$ from experimental data was discussed. A new analysis of the long distance effects in $K_L \to \mu^+\mu^-$ has been reported in [11].

PION β DECAY CKM MATRIX

The two-loop electroweak hadronic contributions to the muon $g - 2$ were reanalized [4]. The present evaluation improves previous ones by the implementation of the current algebra Ward identities and the inclusion of the correct short-distance QCD behaviour of the relevant hadronic Green's function. There is also work in progress in trying to understand qualitatively the vacuum polarization contribution from higher order QED diagrams [15].

MUON $g - 2$

In [5, 6], the long-distance behaviour of two-point functions of flavour non-singlet axial and vector currents in a finite volume, for small quark masses, and at a fixed gauge-field topology was studied, in quenched ChPT. Quenching has a dramatic effect on the vector correlator, while the axial correlator appears to be a robust observable only moderately sensitive to quenching.

QUENCHED ChPT

A calculation of the standard model $\Delta S = 2$ matrix element relevant to indirect CP violation in $K- > \pi\pi$ decays was done [7, 8], which uses Neuberger's chiral formulation of lattice fermions. The resulting bare matrix element is renormalized non-perturbatively. The main result is $B_K^{RGI} = 0.87(8)^{+2+14}_{-1-14}$, where the first error is statistical, the second is systematic and the third is an estimate of the uncertainty associated with the quenched

WEAK MATRIX ELEMENTS WITH CHIRAL FERMIONS

approximation and with the fact that our kaons are composed of degenerate s and d quarks with masses $\sim m_s/2$.

Members of the CPT node have taken part in a number of initiatives aimed at optimizing theoretical predictions to enhance the physics output of major high energy flavor physics experiments [12, 14].

Research Objectives

The research objectives remain as stated in the proposal: a more accurate determination of higher order hadronic contributions to the muon $g-2$, the determination of chiral parameters from lattice simulations, phenomenology of heavy-to-light transitions, observables of CP violation and determination of CKM matrix elements, rare kaon decay modes.

Networking

E. de Rafael, D. Greynat, S. Friot and M. Knecht have attended the meeting in Orsay.

Training

S. Necco has been hired for two years starting Oct. 1st 2003.

References

[1] **T. Hambye, S. Peris and E. de Rafael**, $\Delta I = 1/2$ and ϵ'/ϵ in large-N_c QCD, JHEP **0305**, 027 (2003) [arXiv:hep-ph/0305104].

[2] **D. Becirevic, J. Charles, A. LeYaouanc, L. Oliver, O. Pène and J. C. Raynal**, Possible explanation of the discrepancy of the light-cone QCD sum rule calculation of $g_{D^*D\pi}$ coupling with experiment, JHEP **0301**, 009 (2003) [arXiv:hep-ph/0212177].

[3] **V. Cirigliano, M. Knecht, H. Neufeld and H. Pichl**, The pionic beta decay in chiral perturbation theory, Eur. Phys. J. C **27**, 255 (2003) [arXiv:hep-ph/0209226].

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[5] **P. H. Damgaard, P. Hernandez, K. Jansen, M. Laine and L. Lellouch**, Finite-size scaling of vector and axial current correlators, Nucl. Phys. B **656**, 226 (2003) [arXiv:hep-lat/0211020].

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[7] N. Garron, L. Giusti, C. Hoelbling, L. Lellouch and C. Rebbi, B_K from quenched QCD with exact chiral symmetry [arXiv:hep-ph/0306295].

[8] N. Garron, L. Giusti, C. Hoelbling, L. Lellouch and C. Rebbi, B_K from quenched overlap QCD, Nucl. Phys. Proc. Suppl. **119**, 356 (2003) [arXiv:hep-lat/0212015].

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[12] M. Battaglia *et al.*, *The CKM matrix and the unitarity triangle* [arXiv:hep-ph/0304132].

[13] L. Lellouch, *Phenomenology from lattice QCD*, Plenary talk at the 31st Conference on High Energy Physics (ICHEP 2002), Amsterdam, The Netherlands, 24-31 July 2002, Nucl. Phys. Proc. Suppl. **117**, 127 (2003) [arXiv:hep-ph/0211359].

[14] J. Flynn, L. Lellouch and G. Martinelli, *The CKM lattice working group initiative* [arXiv:hep-lat/0209167].

[15] S. Friot, D. Greynat and E. de Rafael, work in progress.

Author names in boldface indicate joint publications.

3.5 CNRS-IN2P3 Orsay

Participant Number 5 : CNRS-IN2P3 Orsay, Paris

Jan Stern (75%), Bachir Moussallam (75%), Saro Ong (25%), Hagop Sazdjian (50%), Johannes Hirn (Ph.D. Student) (50%) - (IPN - Orsay); Christian Carimalo (25%) - (LPNHE, Universite Paris 6); Alain Le Yaouanc (25%), Luis Oliver (75%), Olivier Pène (25%), Jean-Claude Raynal (25%), S. Descotes-Genon (50%) - (LPT - Orsay); T.N. Pham (50%) - (CPhT - Ecole Polytechnique);

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Total: 12 researchers $\equiv$ 66 p-m/y (average 5.5 p-m/y)

Scientific Highlights

- The heavy quark limit of QCD

  i) A systematic study of Bjorken-like sum rules in the heavy quark limit of QCD has been performed [4, 5, 6]. New results come from considerations of the non-forward amplitude and the systematic use of particular boundary conditions that allow to put bounds on derivatives of the Isgur-Wise function [5, 6, 14]. Furthermore, the coupling $g_{DD^*\pi}$ has been studied within QCD sum rules [3]. The problem of duality in the semi-leptonic inclusive decays of heavy mesons has been discussed.

  ii)QCD factorisation in the heavy quark limit $m_b \to \infty$ has been investigated in the radiative B-decays $B \to \gamma l\nu$, $B \to \gamma\gamma$ and $B \to \gamma l^+ l^-$. Resummation of large Sudakov logarithms present at all orders of perturbation theory has been discussed in the framework of the "Soft Collinear Effective Theory" [8, 9].

- B-decays and CP asymmetry

  Determination of CP asymmetry (angle γ) in the B-decays $B^- \to \pi^+\pi^- K^-$ and $B^- \to K^+K^-K^-$ has been studied [7, 15]. Penguin contributions to the decays $B \to K\pi$ and $B \to \pi\pi$ [1] as well as non-factorisable contributions to $B \to \chi_{c0} K^-$ [2] have been analyzed.

  These subjects are also developed in the PhD thesis by Claudia Isola, defended in December 2002 at Ecole Polytechnique.

- Bound State Equation in the Wilson Loop Approach

  We have studied the properties of the Wilson loop in QCD for large contours, for which the minimal surfaces are solutions of the corresponding loop equations in the limit of a large number of colours. Concentrating on gauge invariant two-particle Green function, we have obtained a covariant three-dimensional bound state equation for the quarkonium system. The latter has a similar structure as the Breit-Salpeter equation, in which the interaction potentials are provided by the energy-momentum vector of the straight segment joining the quark to the antiquark and carrying a linear energy density equal to the string tension. The behavior and properties of the equation in the non relativistic and ultrarelativistic limits were studied [10].

  These subjects are also developed in the PhD thesis by Frederic Jugeau, defended in June 2003 at IPN Orsay.

- Roy-Steiner Equations for πK scattering

  We have derived a set of six coupled equations of the Roy and Steiner type for the S- and P- waves of the $\pi K \to \pi K$ and $\pi\pi \to K\bar{K}$ amplitudes. These equations are treated in the modern way, as a boundary value problem. The range of validity and the multiplicity of solutions are discussed. Precise numerical solutions are obtained in the range $E < 1\,\mathrm{GeV}$ which make use as input, for the first time, of most accurate data available at $E > 1\,\mathrm{GeV}$ for both $\pi K \to \pi K$ and $\pi\pi \to K\bar{K}$ amplitudes. Our main result is to determine the region of allowed values for the two S-wave scattering lengths which are significantly constrained by the boundary conditions. We can then compute a large set of threshold as well as subthreshold expansion parameters. The latter are well suited for matching with ChPT expansion. We determine in this way a number of $0(p^4)$ chiral couplings L_i, in particular, L_4 which is OZI suppressed [11, 16].

- Three-Flavour Chiral Perturbation Theory revisited

  We have investigated the effect of vacuum fluctuations of $\bar{s}s$ pairs on three flavour ChPT. The latter are described by the LEC's L_4 and L_6 which are suppressed at large-N_C, violate the OZI-rule and are poorly known. A small deviation of these constants from their "critical values" (-0.51×10^{-3} and -0.26×10^{-3} respectively) would imply a significant suppression of $N_f = 3$ order parameters $\Sigma(3)$ (quark condensate) and $F^2(3)$ (GB decay constant) compared to their respective values in the $N_f = 2$ chiral limit [12]. As a consequence, vacuum fluctuations of massive $\bar{s}s$ pairs may destabilise the standard perturbative reexpression of order parameters $m_s\Sigma(3)$ and F_0^2 in terms of observable Goldstone boson masses and decay constants. We propose a non perturbative solution of this problem and we apply it to the three-flavour analysis of $\pi\pi$ scattering. We show that the last data imply the lower bound for the quark mass ratio $r = m_s/m > 14$ with 95% confidence level. The problem of chiral extrapolations of unquenched lattice data is also discussed [13].

Networking

- The Orsay-PARIS node has organized the 2nd EURIDICE COLLABORATION MEETING held on 6-8 February 2003 at IPN Orsay, Universite de Paris-Sud

  The Meeting was attended by 50 participants. There have been 30 oral contributions (30' each), most of them (25) by members of our network and the remaining 5 by external collaborators (R. Baldini and C. Biscari from LNF, J.F. Donoghue from University of Massachussets at Amherst, L. Girlanda from ECT* Trento and G. Herdoiza from LPT - Orsay.

  Parallel meetings of 5 working groups have been organized.

- In October 2002, T.N. Pham visited Bari to collaborate with G. Nardulli and P. Colangelo on B-decays and CP asymmetry. G. Nardulli (December 2002) and P. Colangelo (in February 2003) visited Ecole Polytechnique and IPN-Orsay to continue this collaboration and to give seminars.

- G. Giusti (Marseille and CERN) visited IPN-Orsay in December 2002, to give a talk and discuss chiral extrapolations.

- The subjects of πK interaction and three-flavour ChPT are of a common interest with the Bern and Lund nodes. Various contacts have been established at the occasion of Meetings organized by the Network (1st and 2nd Collaboration Meetings, Hadatom2002 in CERN October 02) as well as by e-mail. Sophisticated numerical computer programs concerning the dispersive analysis of the scalar form-factors of Goldstone bosons have been shared between the Orsay and Lund nodes.

- Johanes Hirn visited Durham in July 2003 to discuss with M. R. Pennington his predoctoral stay at IPPP Durham funded by the network.

Networking costs born by the contract:

i) J. Stern and L. Oliver: 1st Euridice Collaboration Meeting Frascati, October 2002.
ii) L. Giusti (Marseille+CERN): Visit to Orsay, December 2002
iii) L. Girlanda (ECT* Trento): Visit to Orsay, February 2003
iv) T.N. Pham and L. Oliver: Workshop on the CKM Unitarity triangle IPPP- Durham, April 2003
v) J. Hirn: Visit and discussions at Durham, July 2003
vi) B. Moussallam: Chiral Dynamics 2003, Bonn, September 2003

Single publications and talks of the node

References [4]-[16]

References

[1] C. Isola, M. Ladisla , G. Nardulli, T.N. Pham and P. Santorelli: "Charming penguin contributions to charmless B-decays into two pseudoscalar mesons", Phys. Rev. D65, 09 4005 (2002).

[2] P. Colangelo, F. de Fazio and T. N. Pham: "$B^- \to \chi_{c,0} K^-$ decay from charmed meson scattering" Phys. Lett, B 542 , 71 (2002)

[3] D. Becirevic, J. Charles, A. Le Yaouanc, L. Oliver, O. Pene and J.-C. Raynal: "Possible explanation of the discrepancy of the light-cone QCD sum rule calculation of $g_{D*D\pi}$ coupling with experiment" JHEP 0301, 009 (2003) [hep-ph/0212177]

[4] A. Le Yaouanc , L. Oliver and J.-C. Raynal: "Sum rules in the heavy quark limit of QCD" Phys. Rev. D67, 114009 (2003). [hep-ph/0210233]

[5] A. Le Yaouanc, L. Oliver and J.-C.Raynal: "Bounds on the derivatives of the Isgur-Wise function from sum rules in the heavy quark limit of QCD" Phys. Lett B557 , 297, (2003).

[6] A. Le Yaouanc, L. Oliver and J.-C. Raynal: "Lower bounds on the curvature of the Isgur-Wise function" [hep-ph/0307197]

[7] S. Fajfer, R.J. Oakes and T.N. Pham: "CP violating phase γ and the partial width asymmetry in $B^- \to \pi^+\pi^- K^-$ and $B^- \to K^+ K^- K^-$ decays" Phys. Letters B539, 67, (2002).

[8] S. Descotes-Genon and C.T. Sacharajda: "Factorization, the light-cone distribution amplitude of the B-meson and the radiative decay $B \to \gamma l \nu_l$." Nucl.Phys. B650 (2003), 356 . [hep-ph/0209216]

[9] S. Descotes-Genon and C.T. Sacharajda: "Universality of non perturbative QCD effects in radiative B-decays", Phys. Letters B557, (2003), 213 . [hep-ph/0212162]

[10] F. Jugeau and H. Sazdjian: "Bound state equation in the Wilson loop approach with minimal surfaces", Nucl. Phys B670, (2003) , 221. [hep-ph/0305021]

[11] P. Buettiker, S. Descotes-Genon and B. Moussallam: "A re-analysis of πK scattering a la Roy and Steiner", [hep-ph/0310283]

[12] S. Descotes-Genon, L. Girlanda and J. Stern: "Chiral order and fluctuations in multi-flavour QCD", Eur.Phys. J. C27 (2003), 115

[13] S. Descotes-Genon, N.H. Fuchs, L. Girlanda and J. Stern: "Resumming QCD vacuum fluctuations in three-flavour Chiral Perturbation Theory", [hep-ph/0311120].

[14] A. Le Yaouanc, L. Oliver and J.-C. Raynal: "Bounds on the derivatives of the Isgur-Wise function" Invited talk at 2nd Workshop on the CKM Unitarity triangle, Durham, England, April 2003, eConf C0304 052, WG111 (2003)

[15] T. N. Pham : "CP asymmetry in $B^- \to \pi^+\pi^- K^-$ and $B^- \to K^+ K^- K^-$ decays" [hep-ph/0306271]. Invited talk at the Workshop on the CKM Unitarity Triangle, IPPP Durham, April 2003 ,eConf C0304052.

[16] P. Buettiker, S. Descotes-Genon and B. Moussallam: "πK scattering inputs to ChPT", [hep-ph/0310045]. Talk presented at the 10th QCD international conference, Montpellier 2-8 July 2003.

3.6 UK Durham/Oxford

Participant Number 6 : DUR, UK Durham/Oxford

M. R. Pennington (*Durham*) (25%); *Oxford*: F. E. Close (50%), R. H. Dalitz (25%), J.J. Dudek (100%); *Manchester*: A. Donnachie (40%); *Durham*: M. E. Boglione (60%), K. Benhaddou (50%)

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Total: 7 researchers ≡ 42 p-m/y

Scientific Highlights

The work of the UK node has focussed on what recent data can teach us about the hadron spectrum and dynamics, and their relation to QCD. These studies have been given fresh impetus by the discovery of candidates for states beyond the quark model in a number of recent experiments at BaBar, Belle and JLAB, for instance. Working closely with the experimental groups involved, the interpretation of these results is likely to remain the focus of study for some time to come.

Travel paid by Durham

1. Euridice Collaboration Meeting, Orsay, Paris, February 2003. M.R. Pennington.

2. QCD@Work, Conversano, Italy, June 2003: M.R. Pennington part of travel.

Relevant Publications

1. F.E. Close and Qiang Zhao (Univ. of Surrey)

   On baryon-antibaryon coupling to two photons, hep-ph/0210277; Physics Letters B553 (2003) 211-216.

2. F.E. Close, A. Donnachie and Yu.S. Kalashnikova

   Radiative decays: a new flavour filter, hep-ph/0210293; Physical Review D67 (2003) 074031.

3. F.E. Close and W. Melnitchouk,

   Symmetry breaking and quark-hadron duality in structure functions, hep-ph/0302013; Physical Review C68 (2003) 035210.

4. M. Boglione and M.R. Pennington,

   Towards a model independent determination of the $\phi \to \gamma f_0$ coupling, hep-ph/0303200; EPJC in press.

5. F.E. Close and J.J. Dudek,

   Electroweak production of hybrid mesons in a Flux-Tube simulation of Lattice QCD, hep-ph/0304243.

6. Qiang Zhao and F.E. Close,

   Locality of quark-hadron duality and deviations from quark counting rules above resonance region. hep-ph/0305017.

7. T. Barnes, F.E. Close and H.J. Lipkin,

   Implications of a DK molecule at 2.32 GeV, hep-ph/0305025.

8. F.E. Close and S. Godfrey,

   Charmonium hybrid production in exclusive B meson decays, hep-ph/0305285.

9. F.E. Close and J.J. Dudek,

   Hybrid meson production by electromagnetic and weak interactions in a Flux-Tube simulation of lattice QCD, hep-ph/0308098.

10. F.E. Close and J.J. Dudek,

    The "forbidden" decays of hybrid mesons to $\pi\rho$ can be large, hep-ph/0308099.

11. F.E. Close and P.R. Page,

    The $D^{*0}\overline{D}^{0}$ threshold resonance, hep-ph/0309253.

12. M.R. Pennington,

    In the debris of hadron interactions lies the beauty of QCD (Part I), Hep-ph/0309228; Proceedings of Workshop on Gluonic Excitations, Jlab, May 2003 (to be published).

13. M.R. Pennington,

    In the debris of hadron interactions lies the beauty of QCD (Part II), hep-ph/0310186; Proceedings of International Workshop on QCD: QCD@Work2003, Conversano, June 2003 (eConf C030614) (to be published).

3.7 Lund University

Participant Number 7 : ULUND Lund University

Lund: Johan Bijnens (10 m/y 83%), P. D'Honte, F. Persson (Ph.D. Students 10 m/y 83%), Post-doc (non EU, 12 m total 25%)   Total: 33 m/y

Oslo: Jan Eeg (10 m/y 83%), A. Hiorth (Ph.D. Student 10 m/y 83%)   Total: 20 m/y

Total: 6 researchers ≡ 53 p-m/y

SCIENTIFIC STAFF

Scientific Highlights

The Lund node and the Oslo subnode have made strong progress on several points. The three main achievements are:

i) For the determination of V_{us} the two-loop corrections in the isospin limit have been calculated. These corrections were found to be significant and fully calculable. All unknowns can be determined experimentally in related experiments. This closes one of the remaining obstacles in improving the experimental precision on V_{us} from semileptonic kaon decays. [$K_{\ell 3}$ **decays in Chiral Perturbation Theory,** J. Bijnens and P. Talavera, hep-ph/0303103, Nucl.Phys.B669 (2003) 341, **Lund-Barcelona**]

ii) After the earlier Lund-Granada results on nonleptonic matrix elements we have concentrated on understanding qualitatively the source of the various large effects we had seen in the delta I=1=1/2 rule and the gluonic penguin in CP-violation. We have therefore started to construct a systematic ladder resummation based hadronic model which will allow us to analytically study the earlier results which were based on a combination of numerical and analytical results. Here a general conflict between quark counting rules, QCD short distance constraints and saturation by a finite number of resonances was found also for a class of order parameters. [**QCD Short-distance Constraints and Hadronic Approximations,** J. Bijnens, E. Gámiz, E. Lipartia and J. Prades, hep-ph/0304222, JHEP 04(2003)055 **Lund-Granada**]

iii) The Oslo subnode has concentrated on developing a heavy-light chiral quark model (**A heavy light chiral quark model**, A. Hiorth and J.O. Eeg, hep-ph/0206158 Phys. Rev. D 66 (2002) 074001) and applying it to B and D decays. Especially, a systematic study of soft gluonic effects, chiral corrections and $1/m_b$ effects in $B\overline{B}$ mixing has been performed (**Nonfactorizable effects in $B - \overline{B}$ mixing**, A. Hiorth, J.O. Eeg, hep-ph/0301118 Eur. Phys. J. direct **C 30** (2003) 006.) Moreover, soft gluonic effects and chiral loops has been calculated for $B \to D\overline{D}$ processes which have no factorized amplitude (**Nonfactorizable contributions in $\overline{B^0} \to D_s^+ D_s^-$ and $\overline{B_s^0} \to D^+ D^-$ decays.** Jan.O. Eeg, Svjetlana Fajfer, and A. Hiorth,hep-ph/0304112 Phys. Lett. B 570 (2003) 46-52).

Research Objectives

We have obtained progress for the work program in the following areas:

I) Theoretical developments in Effective Field Theories

Here we have made progress in all of the areas of the work program. Quark mass effects have been studied for scalar form factors [1] and $K \to 3\pi$ decays. The scalar form factor

work is important in studying many aspects of the transition from 2 to three flavours. The isospin breaking part in $K \to 3\pi$ is partly finished. The local parts have been calculated and will soon appear. The isospin limit was published earlier [2]. The study of of higher order effects in $K_{\ell 3}$ is also relevant here [3]. These are all work in 3 flavour ChPT. The work [4] contains some unexpected results on large-N_c and short-distance constraints as explained in the highlights. We have now started preliminary explorations of two-loop partially quenched ChPT. This work has been reported at several conferences.

II) Theoretical and Phenomenological Studies

The joint work on CP violation of the Lund-Granada group has been reviewed and updated [5]. The issue of the theoretical higher order uncertainty on the element of V_{us} of the CKM matrix as measured in kaon semileptonic decays has been clarified strongly by the Lund-Barcelona two loop results [3]. The Oslo subgroup has as explained in the highlights performed a systematic study of nonfactorisable amplitudes in terms of chiral loops and soft gluonic effects within the heavy-light chiral quark model.

III) Future experiments and identification of relevant hadronic quantities

Here we have updated and put on a more pedagogical footing the known higher order results relevant for eta decays [6] as part of a larger eta physics update [7]. We have also contributed to the hadronic atom results [8].

Schedule and Milestones

We are on track for all milestones we are involved in.

Publications

1. **Scalar Form Factors in SU(3) Chiral Perturbation Theory,** J. Bijnens and P. Dhonte, LU TP 03-32, hep-ph/0307044

2. $K \to 3\pi$ **Decays in Chiral Perturbation Theory,** J. Bijnens, P. Dhonte and F. Persson, Nucl. Phys. B648 (2003) 317

3. $K_{\ell 3}$ **decays in Chiral Perturbation Theory,** J. Bijnens and P. Talavera, hep-ph/0303103, Nucl.Phys.B669 (2003) 341, see also the published talks at Moriond hep-ph/0304284 and CIPANP2003 hep-ph/0307082.

4. **QCD Short-distance Constraints and Hadronic Approximations,** J. Bijnens, E. Gámiz, E. Lipartia and J. Prades, hep-ph/0304222, JHEP 04(2003)055

5. **Matching the Electroweak Penguins** Q_7 **and** Q_8 E. Gámiz, J. Prades and J. Bijnens hep-ph/0209089 Invited talk given by J.P. at XIV Rencontres de Blois, "Matter Anti-Matter Asymmetry", 18-24 June 2002, and by E.G. at QCD 2002, Montpellier, 2-9 July 2002, to be published in the proceedings

6. **Eta Decays at and Beyond** p^4 **in Chiral Perturbation Theory,** J. Bijnens and J. Gasser, Phys.Scripta T99 (2002) 34 **Lund-Berne**

7. **Production, Interaction and Decay of the eta Meson,** J. Bijnens, (ed.), G. Faldt, (ed.) and B.M.K. Nefkens, (ed.), Phys. Scr. T99 (2002) 1-182

8. **Ground State Energy of Pionic Hydrogen to One Loop,** J. Gasser, M.A. Ivanov, E. Lipartia, A. Rusetsky, Eur.Phys.J.C26 (2002) 13, hep-ph/0206068

9. **A heavy light chiral quark model**, A. Hiorth and J.O. Eeg, hep-ph/0206158 Phys. Rev. D 66 (2002) 074001 [14 pages]

10. **Nonfactorizable effects in $B - \overline{B}$ mixing**, A. Hiorth, J.O. Eeg, hep-ph/0301118 Eur. Phys. J. direct C 30 (2003) 006 [22 pages].

11. **On the short distance part of the QCD anomaly contribution to the $b \to s\eta'$ amplitude,** Jan.O. Eeg, Krešimir Kumerički, and Ivica Picek, hep-ph/0304274 Phys. Lett. B 563 (2003) 87-92.

12. **Nonfactorizable contributions in $\overline{B^0} \to D_s^+ D_s^-$ and $\overline{B_s^0} \to D^+ D^-$ decays.** Jan.O. Eeg, Svjetlana Fajfer, and A. Hiorth,hep-ph/0304112 Phys. Lett. B 570 (2003) 46-52.

13. **The β-term for $D^* \to D\gamma$ within a heavy light chiral quark model** A. Hiorth and J.O. Eeg, hep-ph/0304247

14. **A Heavy-Light Chiral Quark Model applied to $B - \overline{B}$ mixing, $B \to D\eta'$, $B \to D\overline{D}$, and $D^* \to D\gamma$.** Jan O. Eeg, Invited talk at "QCD@work", Conversano, Italy june 2003, to appear in the proceedings.

Networking

In the EURIDICE start off meeting E. Lipartia, F. Persson and J. Bijnens participated while the Orsay meeting was attended by J. Bijnens, P. Dhonte, J.O. Eeg and E. Lipartia. E. Lipartia also participated in the oct 2002 HadAtom meeting. In addition the ongoing Lund-Granada exchange has gone with visits of J. Prades to Lund in september 2002 and august 2003. J. Bijnens also visited Oslo in May 2003.

Young Researchers and PhD Students

Timo Lähde, Finnish, has been hired and will start on 1 oct 2003. One PhD student, A. Hiorth obtained his PhD from Oslo in May 2002.

Difficulties

Due to administrative delays in Oslo the subcontract money for the first year has not been transferred yet.

3.8 University of Helsinki

Participant Number 8 : UHELS University of Helsinki

Nils A. Törnqvist (75%), A. Green (75%), D.-O. Riska (16%), M. Sainio (16%), Julia-Diaz (25% , financed by Euridice), J. Koponen (100%), T. Lähde (50%), P. Piirola 100%)   SCIENTIFIC STAFF

Total: 8 researchers $\equiv$ 55 p-m/y

Scientific Highlights

Work on a review "Mesons beyond the naive quark model" for Physics Reports, together with Claude Amsler/Zürich, CERN. This includes theoretical predictions and experimental observations on possible four-quark states, deuteronlike mesonic states, the light scalars, glueballs and hybrid mesons.

Derivation of the nucleon-nucleon interaction and the associated interaction currents in the large-N_c limit of QCD, and demonstration that the operator structure of all currently used realistic phenomenological interaction models is consistent with the $1/N_c$ expansion.

Derivation of the coupling of eta mesons to constituent quarks from $D_s^* \to D_s \pi^0$ decay.

In the lattice calculations for the heavy-light system the most important new result is that the spin-orbit splitting in D-waves is negligible - something not known earlier.

Research Objectives

N.T. will continue his work in the light meson team of the Particle Data Group, which now prepares for the 2004 edition of the Review of Particle Properties, and work on the recently observed narrow charmonium and charm-strange mesons observed by BaBar, Belle, Cleo and BES - especially the possibility that the 3872 MeV state of Belle is a deuteronlike $D\bar{D}^*$ bound state.

Over the last few months the emphasis has been to extract reliable and accurate S-, P-, D- and F-wave energies of heavy-light mesons on the lattice. There had been earlier measurements by the UKQCD collaboration using the quenched approximation on smaller(courser) lattices, but the present results are a distinct improvement over those. Attempts are now underway to understand the results of the heavy-light lattice calculations in terms of the Dirac/Schrödinger equations. The experience gained on this $Q\bar{q}$ system will hopefully help us to understand baryonic QQq systems with two infinitely heavy quarks.

The study of η-nucleon and nucleus interactions is continuing in collaboration with Warsaw.

Study of the pion-nucleon interaction will continue exploiting constraints from analyticity, unitarity and crossing to fix some of the low-energy constants needed in baryon chiral perturbation theory.

Baryon form factors using different forms of relativistic kinematics are studied. The main goal is to clarify the role played by relativity in the study of baryonic form factors. In that line we are studying both the elastic form factors of nucleons as well as the transition

form factors to the Δ and N(1440) making use of point, front and instant forms of relativistic kinematics.

Quark exchange mechanisms in nuclear reactions are investigated. In particular the deuteron photodisintegration reaction at 2 to 6 GeV. The main goal is to try to establish the bridge between what can be inferred from perturbative QCD and what can be studied making use of baryonic degrees of freedom. Our model explores a quark exchange mechanism that provides the short range repulsion to the nucleon-nucleon interaction in quark models in order to study the deuteron photodisintegration.

Networking

Giulia Pancheri visited U. of Helsinki and Helsinki Institute of Physics, May 24-27 to discuss the network coordination with N. Tornqvist, and to give a seminar and a colloquium.

Conferences

N. Törnqvist participated in the conference "Tenth International Conference on Hadron Spectroscopy (Hadron03)" in Aschaffenburg, Germany 30.8-5.9.2003, special permit obtained from R. Monk.

Training

Dr. Bruno Julia-Diaz, Spanish, age 27, joined the group starting from June 2nd, 2003 with an expected stay of 24 months whereof 13 months would be covered by the EU grant.

Women in Physics: The IUPAP International Conference on Women in Physics, Paris, France, 7-9 March 2002 AIP Conference Proceedings 628, published September 2002 Poster "Female Physicists in Finland" A. Penttil, H. Aksela, U. Lhteenmki, and J. Koponen pp. 159-160.

Publications of the Node

1. "The charge and matter radial distributions of heavy-light mesons calculated on a lattice with dynamical fermions", A.M. Green, J. Koponen, C. Michael and P. Pennanen, Eur. Phys. J. **C28** (2003) 79, hep-lat/0206015.

2. "The radial distributions of a heavy-light meson on a lattice", J. Koponen, A.M. Green, C. Michael and P. Pennanen, Nucl. Phys. Proc. Suppl. **B119** (2003) 638.

3. "The measurement, fitting and interpretation of the charge and matter radial distributions of heavy-light mesons calculated on a lattice with dynamical fermions", A.M. Green, J. Koponen, C. Michael and P. Pennanen, Proceedings of the 5th International Conference on Quark Confinement and the Hadron Spectrum, Lake Garda, September 2002, hep-lat/0212017.

4. "Fixed-t partial wave analysis of πN scattering", P. Piirola and M.E. Sainio, Prog. Part. Nucl. Phys. **50** (2003) 367.

5. "Scaling of hadronic form factors in point form kinematics", F. Coester and D. O. Riska, nucl-th/0306002.

6. "The deuteron as a canonically quantized biskyrmion", A. Acus, J. Matuzas, E. Norvaisas, D.O. Riska, nucl-th/0307010.

7. "Stable $uudd\bar{s}$ pentaquarks in the constituent quark model", Fl. Stancu and D. O. Riska, hep-ph/0307010.

8. "A microscopic NN→NN*(1440) potential", B. Julia-Diaz, A. Valcarce, P. Gonzalez, F. Fernandez, Fourth International Conference on Perspectives in Hadronic Physics, Trieste, May 12-14, 2003, to appear in Eur. J. Phys.

9. "The p(d,d') reaction and the sigma NN*(1440) coupling constant", B. Julia-Diaz, A. Valcarce, F. Fernandez, Second International Conference on Nuclear and Particle physics with CEBAF at Jefferson Laboratory (NAPP 2003), Dubrovnik, Croatia, May 26-31, 2003, to appear in FIZIKA B.

10. "Comment on the narrow charmonium state of Belle at 3871.8 MeV as a deuson", N.A. Törnqvist, hep-ph/0308277.

11. "Mesons beyond the naive quark model", Claude Amsler and Nils A. Törnqvist 68 pages, submitted for publication in Physics Reports, Helsinki-Zurich

12. "On η-π mixing close to the η-Helium threshold", A.M. Green and S. Wycech, nucl-th/0308057, Helsinki-Warsaw

3.9 DESY Zeuthen

Participant Number 9 : DESY Zeuthen

Friedrich Jegerlehner, S. Dürr, K. Jansen, Kei-ichi Nagai (each 6 m/year), M. Kalmykov, O. Tarasov (4 m/year), R. Sommer (3 m/year), J. Gluza (8m/year) **DESY** Total: 43 p-m/y SCIENTIFIC STAFF

W. Kluge, A. Denig, S. Müller, B. Valeriani, C. Bruch (each 12 m/year), T. Selz (6m/year), A. Khodjamirian (4m/year), J. Kühn, K. Chetyrkin (each 3 m/year) **Univ. Karlsruhe** Total: 76 p-m/y

Scientific Highlights

The DESY/Karlsruhe team made substantial progress in the investigation of hadronic effects in electroweak precision observables. This includes the calculation of higher order terms in perturbation theory as well as the evaluation of non–perturbative effects. The latter, in principle, can be evaluated by computer simulation in lattice QCD or in the traditional way by calculating a dispersion integral over hadron production data obtained in e^+e^-–annihilation.

Research Objectives

The research objectives of the Zeuthen/Karlsruhe team are still relevant and achievable. We still consider it to be an important callenging long term project. The experimental activities like the Brookhaven $g-2$ experiment which measured the anomalous magnetic moment of the muon at the unbelievable precision of 0.7ppm as well as the ongoing precision measurements of low energy hadronic cross-sections at KLOE/Dafne (Frascati), CLEO-C (Corlell), BABAR/SLAC (Stanford), BELLE/KEK (Tsukuba), which are needed as an input for the theoretical predictions which confront the $g-2$ experiment, make the project a real "hot topic". Equally important are the attempts to get a deeper understanding of the chiral limit of lattice QCD and of low enery hadron phenomenology. Substantial progress in precision determination of fundamental parameters of the SM/QCD is expected.

Networking

Karlsruhe/Katowice (subnode of DESY Zeuthen and team from Warsaw node) activities [1]–[5]:
Theoretical concepts have been developed which allow to utilize the Radiative Return at KLOE, CLEO-C, BABAR and BELLE for a precise measurement of the pion form factor at low Q^2. The Monte Carlo generator PHOKHARA has been extended to photon emission at small angles and now includes final state radiation in next to leading order. Various strategies have been suggested to test the validity of the model assumptions inherent in this approach. The addition of a larger variety final states and improved parametrizations of the form factors are in preparation.

DESY Zeuthen/Katowice (participant from Warsaw) activities [7, 6]:
We have developed an efficient Monte Carlo program for the simulation of massive particle production including photon radiation. An application to low energy $\pi^+\pi^-$ is now in progress. This will extend previous radiative correction calculations. New developments in the high precision physics have lead to substantial progress in understanding theoretical uncertainties in $(g-2)_\mu$ of the muon and the effective fine structure constant $\alpha_{em}(M_Z)$.

Zeuthen/Berne activities [8]:
The parameters of the effective Chiral Lagrangian from first principles, through finite-size scaling studies in lattice QCD, has been investigated. A determination of the shift $M_\pi(L) - M_\pi$ due to the finite spatial box size L by means of $N_f = 2$ Chiral Perturbation Theory and Lüscher's formula has been performed. The range of applicability of the chiral prediction was investigated.

Zeuthen/Marseille activities [9]:
Other activities concentrated on chiral perturbation theory in the so-called epsilon regime, where the Compton wavelength of the pion is much larger than the box size. This regime allows by finite size scaling techniques to extract low energy constants of the chiral Lagrangian. Another activity is the development of efficient algorithms for dynamical fermions.

Karlsruhe/Frascati/Pisa activities [10]–[21]:
The Karlsruhe group participated in the general activities of the KLOE collaboration (at DAFNE/Frascati) of data taking, data reconstruction and data analysis. The main emphasis was on measuring the cross section $e^+e^- \rightarrow \gamma\gamma^* \rightarrow \pi^+\pi^-\gamma$ at the 1% level. Close collaboration with theoretical groups from Karlsruhe (J.H. Kühn) and Katowice (H. Czyż), DESY Zeuthen (F. Jegerlehner), the University of Pavia (C. Calame Carloni, G. Montagna) and from Henryk Niewodniczanski Institute of Nuclear Physics Cracow (S. Jadach) was essential. The accuracy of the measurement of the cross section for the two pion final state with a real photon emitted in the initial state as a function of energy up to the ϕ resonance is less than 0.5% for the statistical error and of the order of 1-2% for the systematic error. The contribution to the hadronic correction of a_μ is $a_\mu^{\pi\pi} = 378.4 \pm 0.8_{stat} \pm 4.5_{syst} \pm 3.0_{theor} \pm 3.8_{FSR}$ for the interval $0.37, Q^2 < 0.93 GeV^2$, while the collaboration CMD-2 obtained $a_\mu^{\pi\pi} = 378.6 \pm 2.7_{stat} \pm 2.3_{syst+theor}$. The discrepancy between the $e^+e^- \rightarrow \pi^+\pi^-$ cross section and the corresponding result obtained via the CVC-theorem and iso-spin rotation from τ–decay spectral function has not been solved so far. The KLOE data favor the result of Novosibirsk. Different masses for the neutral and the charged ρ–mesons might be responsible for the diverging τ–data.

Visiting scientists from or at other EURIDICE nodes:

- F. Jegerlehner, EURIDICE Collab. Meeting, Frascati, 18th to 20th of October 2002

- M. Czakon, Univ. of Silesia, Katowice [Warsawa node] visiting DESY Zeuthen, 23rd to 28th of October 2002

- R. Sommer, EURIDICE Collab. Meeting, Orsay, 6th to 8th of February 2003

- G. Colangelo, Univ. of Berne, visiting DESY Zeuthen, 19th to 21st of February 2003

- M. Czakon, Univ. of Silesia, Katowice [Warsawa node] visiting DESY Zeuthen, 20th to 30th of June 2003

- K. Kołodziej, Univ. of Silesia, Katowice [Warsawa node] visiting DESY Zeuthen, 5th to 13rd of June 2003

- F. Jegerlehner, DESY Zeuthen visiting Frascati, 16th to 30th of March (TARI 2003)

- F. Jegerlehner, DESY Zeuthen, Frascati, 10th to 13th of April
  Photon 2003, Intern. Conference

- H. Leutwyler, Univ. of Berne, visiting DESY Zeuthen, 1st to 31st of Mai (Preisträger der Humboldt Stiftung)

- J. H. Kühn, Univ. of Karlsruhe, visiting Frascati, vom 18. - 10. 10. 2002

- S. Müller, Univ. of Karlsruhe, EURIDICE Collab. Meeting, Orsay, vom 5. - 9. 2. 2003

- W. Kluge, Univ. of Karlsruhe, EURIDICE Collab. Meeting, Orsay, vom 5. - 10. 2. 2003

- Henryk Czyż, Univ. of Silesia, Katowice [Warsawa node] visiting Univ. of Karlsruhe, 01/11/02 - 31/12/02, 01/07/03 - 31/07/03

- Agnieszka Grzelińska, Univ. of Silesia, Katowice [Warsawa node] visiting Univ. of Karlsruhe, 01/11/02 - 31/01/03, 01/07/03 - 31/07/03

- Elżbieta Nowak, Univ. of Silesia, Katowice [Warsawa node] visiting Univ. of Karlsruhe, 07/07/03 - 31/07/03

Talks at DESY Zeuthen by visitors from other EURUDICE nodes:

- Michal Czakon (Univ. of Silesia, Katovice)
  Two-Loop Electroweak Corrections to Δr
  24-OCT-02, DESY-HU Theorie-Seminar

- Axel Hoefer (Univ. Krakau)
  Measuring the FSR-inclusive $\pi^+\pi^-$ cross section
  6-FEB-03, DESY-HU Theorie-Seminar

- Gilberto Colangelo (Univ. Bern)
  Experimental determination of the chiral condensate
  20-FEB-03, DESY-HU Theorie-Seminar

- Heinrich Leutwyler (Univ. Bern)
  Experimental evidence for the quark condensate
  22-MAY-03, DESY-HU Theorie-Seminar

Talks by F. Jegerlehner:

- DESY Zeuthen, Feb 28/Mar 01, 2003, Workshop on ELECTROWEAK PRECISION DATA AND THE HIGGS MASS, "$\alpha_{\mathrm{em}}(M_Z)$"

- LNF/INFN Frascati, Mar 20, 2003, TARI program 2003, "Theoretical problems of HADRONIC CROSS SECTION measurements at low energies"

- LNF/INFN Frascati, Apr 7-11, 2003, Photon 2003, Intern. Conference, " Theoretical precision in estimates of hadronic contributions to $(g-2)_\mu$ and $\alpha_{\mathrm{em}}(M_Z)$"

Publications in Refereed Journals: Kluge

Study of the decay $\phi \to \pi^+ \pi^- \pi^o$
The KLOE Collaboration
Phys. Lett. **B 561** (2003) 455

$\Gamma(K_L \to \gamma\gamma)/\Gamma(K_L \to \pi^o\pi^o\pi^o)$
The KLOE Collaboration
Phys. Lett. **B 566** (2003) 61

Work Plan

To all the relevant points new results were obtained. The original work plan remains valid.

Postdoctorands

Started 1st of October 2003 at DESY Zeuthen.

Table 6: Assigned funds and total spent so far, during the first three reporting periods, by each node,

N.º Team	(A) Young Vis. Res.	(B) Net--working	(C) Other Dir.Costs	(D) Over head	Total Assigned	Total Spent so far
9 DESY Zeuthen	–	1,656.31	5,250.00	966.88	147,000	7,873.19
Total						

Expenditures born by the Contract

Travelling			Costs
Name	Place	Date	ECU
Jegerlehner	Frascati	Oct 17, 2002	886.43
Sommer	Paris	Feb 6/8, 2003	769.88

Date	Topic	Input	Output
		EURO	EURO
31.08.2002	Saldo per 1. Sep. 02	0,000.00	
2002	Transfer From Coordinator	44,100.00	
2003	Transfer to subnode Karlsruhe		5,250.00
02/03	travelings		1,656,31
	sum		6,906,31
	overhead 14% of 6,906.31		966.88
	sum	44,100.00	7,873.19
31.08.2003	Saldo per 1. Sep. 03	36,226.81	

References

[1] H. Czyz, A. Grzelinska, J. H. Kühn, G. Rodrigo (Zeuthen[Karlsruhe] & War-saw[Katowice])
The radiative return at ϕ- and B-factories: FSR at next-to-leading order,
hep-ph/0308312.

[2] H. Czyz, A. Grzelinska, J. H. Kühn, G. Rodrigo (Zeuthen[Karlsruhe] & War-saw[Katowice])
The radiative return at ϕ- and B-factories: small-angle photon emission at next to

leading order
Eur. Phys. J. C 27 (2003) 563-575, hep-ph/0212225.

[3] H. Czyz, J. H. Kühn, G. Rodrigo (Zeuthen[Karlsruhe] & Warsaw[Katowice])
Radiative return at e^+e^- factories
Nucl.Phys.B(Proc.Suppl.) 116 (2003) 249, hep-ph/0211186.

[4] G. Rodrigo, H. Czyz, J. H. Kühn (Zeuthen[Karlsruhe] & Warsaw[Katowice])
Precision measurement of the hadronic cross-section through the radiative return method
Nucl.Phys.B(Proc.Suppl.)123 (2003) 167, hep-ph/0210287.

[5] G. Rodrigo, H. Czyz, J. H. Kühn (Zeuthen[Karlsruhe] & Warsaw[Katowice])
Radiative Return at NLO: the PHOKHARA Monte Carlo generator
in "Proceedings of the 37th Rencontres de Moriond on Electroweak Interactions and Unified Theories", Les Arcs, France, 9-16 March 2002, hep-ph/0205097.

[6] J. Gluza, A. Hoefer, S. Jadach, F. Jegerlehner (Zeuthen & Warsaw[Katowice/Crakow]),
Measuring the FSR inclusive $\pi^+\pi^-$ cross-section,
Eur.Phys.J.C28:261-278,2003, hep-ph/0212386.

[7] K. Kołodziej, F. Jegerlehner (Zeuthen & Warsaw[Katowice]),
EE4FGAMMA: A program for $e^+e^- \to 4f, 4f\gamma$ with nonzero fermion masses,
hep-ph/0308014.

[8] Finite size effects on M_π in QCD from Chiral Perturbation Theory,
G. Colangelo, S. Dürr, R. Sommer (Berne & Zeuthen),
hep-lat/0209110,

[9] P. H. Damgaard, P. Hernandez, K. Jansen, M. Laine and L. Lellouch (Zeuthen & Marseille),
Finite-size scaling of vector and axial current correlators,
Nucl. Phys. B **656** (2003) 226, [arXiv:hep-lat/0211020].

[10] Measuring the Hadronic Cross Sections via Radiative Return
A. Denig for the KLOE Collaboration, 6th International Symposium on Radiative Corrections, Application of Quantum Field Theory to Phenomenology - RADCOR 2002 and 6th Zeuthen Workshop on Elementary Particle Theory, Loops and Legs in Quantum Field Theory, September 8 -13, 2002, Kloster Banz Nucl. Phys. **B 116** (2003) 243

[11] Hadronic cross section measurements with the KLOE detector
S. E. Müller for the KLOE Collaboration, 2nd EURIDICE Collaboration Meeting, IPN - Orsay, February, 6 - 8, 2003 http://www.lnf.infn.it/kloe/

[12] Physics with DAΦNE-KLOE: The reaction $e^+e^- \to \pi^+\pi^-$ and its relation to the anomalous magnetic moment of the muon
W. Kluge, XXXIV. Arbeitstreffen Kernphysik, Schleching/Obb., 20. - 27. Februar 2003 http://www-ekp.physik.uni-karlsruhe.de/ bartsch/kluge

[13] The detector KLOE at the electron positron collider DAΦNE in Frascati
B. Valeriani for the KLOE collaboration, XXXIV. Arbeitstreffen Kernphysik, Schlech-ing/Obb., 20. - 27. Februar 2003 http://www.lnf.infn.it/kloe/

[14] Hadronic cross section measurement with the KLOE detector
S. E. Müller for the KLOE collaboration, Verhandlungen der Deutschen Physikalischen Gesellschaft, Frühjahrstagung Teilchenphysik, Aachen 10. - 13. März 2003, T 108.6 http://www.lnf.infn.it/kloe/

[15] KLOE results on ϕ radiative decays
B. Valeriani for the KLOE Collaboration, Verhandlungen der Deutschen Physikalischen Gesellschaft, Frühjahrstagung Hadronen und Kerne, Tübingen 17. - 21. März 2003, HK 17.12 http://www.lnf.infn.it/kloe/

[16] Measurement of the e^+e^- hadronic cross section at DAΦNE via radiative return
S. E. Müller for the KLOE Collaboration, International Conference on the Structure and Interactions of the Photon including the 15th International Workshop on Photon-Photon Collisions, LNF of INFN, Frascati, April 7 - 11, 2003 http://www.lnf.infn.it/kloe/ to be published in the Proceedings

[17] KLOE: Results on Hadronic Physics
A. Denig for the KLOE Collaboration, 26th Meeting of the Scientific Committee of LNF, May 30, 2003 http://www.lnf.infn.it/

[18] Determination of $\sigma(e^+e^- \to \pi^+\pi^-)$ from radiative processes at DAΦNE
The KLOE Collaboration, Contributed paper to the International Europhysics Conference on High Energy Physics EPS 2003, July 17-23, 2003, Aachen, Germany and XXI. International Symposium on lepton and Photon Interactions at High Energies LP 2003, Aug. 11-16, 2003, Fermilab, Batavia Ill., hep-ex/0307051

[19] Measurement of the Hadronic Cross Section at DAΦNE with the KLOE Detector
A. Denig for the KLOE Collaboration, Contributed paper to the Xth International Conference on Hadron Spectroscopy (Hadron2003), Aug. 31 - Sept. 6, 2003, Aschaffenburg, Germany

[20] Measurements of hadronic cross sections with KLOE and their relation to the magnetic moment of the muon
D. Leone for the KLOE Collaboration, Talk at the Arbeitstreffen "Hadronen und Kerne" Meißen, Germany, Sept. 8 -11, 2003

[21] Measurement of the Hadronic Cross Section at DAΦNE with the KLOE Detector
S. E. Müller for the KLOE Collaboration, Workshop on e^+e^- in the 1 - 2 GeV range: Physics and Accelerator Prospects, Alghero (Sardinia), Sept. 10-13, 2003

3.10 University of Bern

> Participant Number 10 : UNIBE University of Bern

BERN: **Jürg Gasser** (30%), G. Colangelo (50%), Ch. Greub (50%), T. Hurth (50%), B. Kubis (100%), I. Scimemi (100%), M. Verbeni (100%);
K. Bieri (100%), M. Schmid (100%), J. Schweizer (100%), P. Zemp (100%) (Ph.D. Students)
ZÜRICH: D. Wyler (30%); M. Büchler (100%), E. Lunghi (40%), A. Nyffeler (50%), W. Porod (40%);
U. Andri (50%), S. Schilli (50%), R. Zwicky (50%) (Ph.D. students)

SCIENTIFIC STAFF

Total: 19 researchers $\equiv$ 259 p-m/y

Scientific highlights

We have investigated isospin breaking effects in low-energy effective theories from a general point of view [1]. Applications to QCD are presently being worked out.

[1] J. Gasser, A. Rusetsky and I. Scimemi, *Electromagnetic corrections in hadronic processes*, arXiv:hep-ph/0305260, Eur. Phys. J. C, in press. [Project objective: ChPT; Milestones: Isospin breaking; Teams involved: Bern]

Research objectives

The research objectives are achievable.

Training

Dr. B. Kubis has joined our group on November 1, 2002. His scientific activities are described below.

Workplan

Concerning the **workplan** in general, our node is well in phase with what was proposed in the working plan. Details of what we have been doing/are doing right now is given in the following summaries.

- *Theoretical development of effective field theories*

1. We have investigated isospin breaking effects in low-energy effective theories from a general point of view [1].

   [1] J. Gasser, A. Rusetsky and I. Scimemi, *Electromagnetic corrections in hadronic processes*, arXiv:hep-ph/0305260, Eur. Phys. J. C, in press.

2. Lattice QCD and ChPT. We have considered the renormalization group equation in ChPT [2] - with applications to Lattice QCD to be worked out [3].

[2] M. Buchler and G. Colangelo, *Renormalization group equations for effective field theories*, arXiv:hep-ph/0309049, to appear in Eur. Phys. J. C.

[3] M. Buchler and G. Colangelo, work in progress.

- *Theoretical and phenomenological studies*

1. Presently, we evaluate pion electroproduction at one loop order in the Becher-Leutwyler formalism, and compare the result with HBChPT [1].
[1] B. Kubis, V. Bernard and Ulf-G. Meißner, work in progress.

2. We are investigating the rare K decay $K_{e3\gamma}$ in light of the Low-theorem [2].
[2] J. Gasser, B. Kubis, M. Verbeni and N. Paver, work in progress.

3. We investigate the low-energy contribution to the hadronic vacuum polarization in $(g-2)_\mu$ [3].
[3] I. Caprini, G. Colangelo, F. Jegerlehner and H. Leutwyler, work in progress.

4. We have performed a NLO calculation of CP-violating effects in $K \to 3\pi$ decays [4].
[4] E. Gamiz, J. Prades and I. Scimemi, *CP-violating asymmetries in $K \to 3\pi$ in the standard model*, arXiv:hep-ph/0305164.

5. We worked on various topics concerning the inclusive rare B meson decays $B \to X_s\gamma$ and $B \to X_{s,d}\ell^+\ell^-$ [5,6].
[5] K. Bieri, C. Greub and M. Steinhauser, Phys. Rev. D **67** (2003) 114019 [arXiv:hep-ph/0302051].
[6] H. M. Asatrian, K. Bieri and C. Greub, in preparation.

6. We have considered subleading collinear operators [7].
[7] A. Hardmeier, E. Lunghi, D. Pirjol and D. Wyler, arXiv:hep-ph/0307171.

- *Future Experiments and identification of relevant hadronic quantities*

1. We have continued the investigation of the energy spectrum and decay of the πK atoms and of pionic hydrogen [1]. The leading and next-to-leading corrections for the energy spectrum for S-states and for the decay width of the ground state have been determined.

[1] J. Schweizer and P. Zemp, work in progress.

Talks at International Conferences, Proceedings

1. K. Bieri and C. Greub, *Review on the inclusive rare decays $B \to X_s\gamma$ and $B \to X_d\gamma$ in the standard model*, Talk given by C. Greub at the International Europhysics Conference on High-Energy Physics (HEP 2003), Aachen, Germany, 17-23 Jul 2003, arXiv:hep-ph/0310214, to appear in the Proceedings.

2. G. Colangelo, Invited talk on *Experimental determination of the quark condensate* at the 5th International Conference "Quark confinement and the hadron spectrum", Gargnano, Garda Lake, 10-14 September 2002, to appear in the Proceedings.

3. G. Colangelo, Invited talk on *Dispersive treatment of $K->\pi\pi$* at the second international workshop on Hadronic physics "Effective theories to low energy QCD", Coimbra, Portugal September 25-29 2002. Published in AIP Conf.Proc.660:25-33,2003

4. G. Colangelo, Invited talk on *Experimental determination of the quark condensate* at the XXXVIIIth Rencontres de Moriond on QCD, March 22-29 2003, to appear in the Proceedings.

5. J. Gasser, *Pionic Hydrogen: Ground state Energy to one Loop*, Third workshop on hadronic atoms (HadAtom02), Oct. 14-15, 2002, CERN, Switzerland, arXiv:hep-ph/0301266.

6. J. Gasser, *Light Quark Dynamics* Lectures given at 41st Internationale Universitaetswochen fuer Theoretische Physik: Flavor Physics (IUTP 41), Schladming, Styria, Austria, 22-28 Feb 2003, to appear in the Proceedings.

7. A. Nyffeler, *Theoretical status of the muon g-2*, Talk given at 38th Rencontres de Moriond on Electroweak Interactions and Unified Theories, Les Arcs, France, 15-22 Mar 2003, arXiv:hep-ph/0305135, to appear in the Proceedings.

8. A. Nyffeler, *Hadronic light-by-light scattering contribution to g(mu)-2*, Presented at 6th International Symposium on Radiative Corrections: Application of Quantum Field Theory Phenomenology (RADCOR 2002) and 6th Zeuthen Workshop on Elementary Particle Theory (Loops and Legs in Quantum Field Theory), Kloster Banz, Germany, 8-13 Sep 2002, in: Nucl. Phys. Proc. Suppl. **116** (2003) 225 [arXiv:hep-ph/0210347].

9. I. Scimemi *Hadron processes and electromagnetic corrections* Talk given at QCD@work 2003, International workshop on QCD, Conversano, Italy, 14-18 June 2003, to appear in the Proceedings.

10. T. Hurth and E. Lunghi, *On Exclusive and Inclusive Rare B Decays: CKM Phenomenology and New Physics Reach*, 2nd Workshop on the CKM Unitarity Triangle, Durham, England, 5.-9. April 2003, eConf **C0304052** (2003) WG206 [hep-ph/0307142].

Presentations at meetings and conferences

1. G. Colangelo, Invited lecture series on *Introduction to Chiral Perturbation Theory* Graduiertenkolleg of the University of Heidelberg, October 7-11, 2002.

2. G. Colangelo, Two talks: *Determination of V_{us} and chiral dynamics in K decays* and *The hadronic contribution to a_μ below one GeV*, given a the "XV IFAE: Incontri sulla Fisica delle Alte Energie", Lecce, Italy, 23-26 April 2003.

3. J. Gasser, *Elements on ChPT*, invited talk given at the Erice School on Nuclear Physics 2002, Erice, It, Sep. 16-24, 2002.

4. J. Gasser, *Lattice calculations and ChPT*, invited talk given at lattice workshop "Finite fermion action and chiral symmetry", Bern, Sep. 16-19, 2002.

5. C. Greub, *Next-to-next-to-leading corrections to $B \to X_s \ell^+ \ell^-$ in the standard model*, Talk given at the first EURIDICE meeting, Frascati, Italy, October 17-20, 2002.

6. J. Schweizer, *Generating functional for pions at low energies and virtual photons*, Talk given at Euridice Start-off Collaboration Meeting, Frascati, Italy, 18-20 October 2002.

Joint Publications

[1] Nodes: Bern-Frascati-Valencia
M. Battaglia *et al.*, *The CKM matrix and the unitarity triangle*, arXiv:hep-ph/0304132, to appear as CERN Yellow Report.

[2] Nodes: Bern-Granada
E. Gamiz, J. Prades and I. Scimemi, *CP-violating asymmetries in $K \to 3\pi$ in the standard model*, arXiv:hep-ph/0305164.

3.11 Universität Wien

Participant Number 11 : Vienna, Universität Wien

Gerhard Ecker (50%), Helmut Neufeld (50%), Heinz Rupertsberger (25%), Reinhold A. Bertlmann (50%), Walter Grimus (25%), Beatrix C. Hiesmayr (50%), Katharina Durstberger (100%), Rene Unterdorfer (50%)

SCIENTIFIC STAFF

Total: 8 researchers ≡ 48 p-m/y

Scientific Highlights

Within the framework of chiral perturbation theory with virtual photons and leptons, an updated analysis of pionic beta decay was performed including all electromagnetic contributions of order $e^2 p^2$ [1]. The extraction of the Cabibbo-Kobayashi-Maskawa (CKM) matrix element $|V_{ud}|$ from the reaction $\pi^\pm \to \pi^0 e\nu$ was discussed. The applied theoretical method is consistent with the analogous treatment of $K_{\ell 3}$ decays and the determination of $|V_{us}|$. The implications of large-N_c and chiral symmetry for the mass spectra of meson resonances were investigated [2]. Unlike for most other mesons, the mass matrix of the light scalars deviates strongly from its large-N_c limit. The possible assignments for the lightest scalar nonet surviving the large-N_c limit were discussed. As part of a long-term project, the first complete analysis of isospin breaking for direct CP violation in $K^0 \to 2\pi$ decays was carried out [3]. A destructive interference between three different sources of isospin violation in the CP violation parameter ϵ' was found.

In collaboration with colleagues from Barcelona, extensions and tests of Bohr's complementarity principle through the quantum marking and eraser procedure were discussed. It was shown [4] that the neutral kaon system is very suitable to discuss quantum marking and eraser operations and that a single experimental set-up for neutral kaons covers the physics of a series of different quantum marking and eraser experiments performed with photons. Experiments of this type are highly desirable and might be performed at DaΦne. Furthermore, a quantitative formulation of Bohr's complementary principle and interferometric duality for the neutral kaon system was discussed [5]. Recent experiments by CPLEAR can easily be interpreted in terms of "neutral kaon interferometry".

Publications

[1] V. Cirigliano, M. Knecht, H. Neufeld and H. Pichl, The pionic beta decay in chiral perturbation theory, Eur. Phys. J. C27 (2003) 255. **Joint publication Marseille/Valencia/ Vienna.**

[2] V. Cirigliano, G. Ecker, H. Neufeld and A. Pich, Meson resonances, large-N_c and chiral symmetry, JHEP 0306 (2003) 012. **Joint publication Valencia/Vienna.**

[3] V. Cirigliano, G. Ecker, H. Neufeld and A. Pich, Isospin violation in ϵ', hep-ph/0307030, to appear in Phys. Rev. Lett. **Joint publication Valencia/Vienna.**

[4] A. Bramon, G. Garbarino and **B.C. Hiesmayr**, Quantum marking and quantum erasure for neutral kaons, quant-ph/0306114. **Joint publication Barcelona/Vienna.**

[5] A. Bramon, G. Garbarino and **B.C. Hiesmayr**, Quantitative duality and neutral kaon

interferometry in CPLEAR experiments, hep-ph/0307047. **Joint publication Barcelona/ Vienna.**

[6] R.A. Bertlmann, K. Durstberger and **B.C. Hiesmayr**, Decoherence of entangled kaons and its connection to entanglement measures, Phys. Rev. A 68 (2003) 0121111.

[7] G. Ecker, Two-pion contribution to the muon magnetic moment, hep-ph/0211311, Proc. of Hadron Structure '02, Eds. J. Urban and J. Vrlakova, Sept. 2002, Herlany, Slovakia.

Research Objectives

The research objectives of the Vienna group, as part of the objectives set down in Annex 1 of the contract, are still relevant and achievable.

The chiral group is continuing its work along several directions. The study of isospin breaking in $K \to 2\pi$ decays is nearing completion and will be published during the next reporting period. A detailed numerical study of K_{e3} decays to $\mathcal{O}(p^6, (m_d - m_u)p^2, e^2p^2)$ is also in an advanced state. In the same spirit, a numerical study of $K_{\mu3}$ decays is being planned. A new project on rare kaon decays will be started together with the group in Frascati. The problem of bridging the gap between low and high energies for various Green functions is under investigation together with the group in Valencia.

The Quantum Mechanics group will soon issue a paper where entangled spin-$\frac{1}{2}$ systems and applications for the Berry phase are considered. An experimental realization of the proposed setup with neutron interferometry is discussed, in close collaboration with the Atominstitut of Austrian Universities in Vienna. The collaboration with Barcelona is also continuing. On one side, different analytically solvable systems are investigated to demonstrate that a common quantitative formulation of Bohr's complementarity principle is possible. Furthermore, a new concept of a quantum marking and erasure experiment is under study that is only realizable for the neutral kaon system.

Work Plan

The work plan for the current period foresees no significant departures from the one outlined in Annex I. The research efforts of the Vienna group are as indicated in the contract, with the important qualification that the Euridice postdoc for our group, Roland Kaiser, has started his appointment on Oct. 1, 2003 and will work full-time for the project until Sept. 30, 2005.

Organization and Management

In addition to participating in the first two Collaboration Meetings in Frascati and Orsay, the Vienna group has communicated their results in various international meetings and workshops (CERN-NA48/2 Kaon Meeting (Geneva), Hadron Structure '02 (Herlany, Slovakia), Int. Workshop on Exotic Atoms (Vienna), School on Applications of Effective Field Theories (Milano), Quantum Theory: Reconsideration of Foundations-2 (Växjö, Sweden)). Helmut Neufeld spent 2 weeks at the Valencia Institute in April 2003.

Secondments

- B. Hiesmayr (Vienna) $\longrightarrow$ Barcelona;

- R. Unterdorfer (Vienna) $\longrightarrow$ Frascati.

Training

The postdoctoral position of the Vienna node was announced in the fall of 2002 resulting in some 35 applications, of which 23 came from EU member states and associated states. The position was awarded to Dr. Roland Kaiser (Switzerland) who has taken up his appointment on Oct. 1, 2003.

3.12 Warsaw University

Participant Number 12 : Warsaw, Warsaw University - Poland

M. Krawczyk (UW, Warsaw University) (5 pm/y=42%), M. Misiak (UW) (6 pm/y= 50%), L. Łukaszuk, S. Wycech (IPJ, Sołtan Institute of Nuclear Studies, Warsaw) (2x6 pm/y=2x50%), H. Czyż (US, Silesia University-Katowice) (8 pm/y=67%), U. Jezuita-Dąbrowska, P. Jankowski (Ph.D. Students, Warsaw) and A. Grzelińska, E. Nowak (Ph.D. Students, Katowice) (4x7 pm/y=4x58%)   Total: 9 researchers

SCIENTIFIC STAFF

Scientific Highlights

Katowice team in collaboration with the Karlsruhe sub-node, developed Monte Carlo tools, to exploit radiative return method for hadronic e^+e^- cross section, the unique possibility for a measurement over a wide range of energies, The Monte Carlo generator PHOKHARA, which includes next-to-leading order corrections from virtual and real photon emission, has been extended [1,2] (PHOKHARA 2.0) into the collinear region, using recent results for the virtual corrections.

A further extension of PHOKHARA (version 3.0) incorporates NLO corrections to final-state radiation (FSR) [3]. The impact of combined ISR and FSR on various distributions was investigated and methods were presented, which will allow to extract of the pion form factor. The impact of FSR contribution on the anomalous magnetic moment of the muon was evaluated. In collaboration with the INFN (Bologna) node the work concentrated on numerical evaluation of two-loop scalar integrals [4] relevant for precise evaluation of Standard Model observables.

We performed a K-matrix analysis of for $p + d \rightarrow 3\,\mathrm{H}\,\pi^+$ and $p + d \rightarrow 3\,\mathrm{He}\,\pi^0$, measured recently at Jullich, at the threshold where large effect due to $\pi^0 - \eta$ mixing magnified by $\eta - He$ guasi bound state are expected and find the $\pi^0 - \eta$ mixing parameter to be θ =0.010(5), a value roughly consistent with quark model estimates [5].

New, radiatively generated, LO quark (u,d,s,c,b) and gluon densities in a real, unpolarized photon were constructed. We performed global 3-parameter fits, based on LO DGLAP evolution equations, to all available data for the structure function $F_2^\gamma(x, Q^2)$. We adopt a new theoretical approach called ACOT(chi), originally introduced for the proton, to deal with the heavy-quark thresholds [6]. Other aspects related to structure of photon was also considered, among other how important are interference terms in semi-inclusive processes [7], and future measurements at Photon Collider [8]

In the paper [9] it was suggested for the first time that the $0(\alpha_s^2)$ corrections to $B \rightarrow X_s$ gamma can be calculated using an extrapolation in the charm quark mass. The report [10] contains a summary of the current phenomenological knowledge on the quark mixing and CP violation in the SM. The part written by A. Ali and M. Misiak explains the role of rare radiative B decays in the CKM matrix determination. The current status of the NNLO QCD calculations of the decays $b \rightarrow sl^+l^-$ and $b \rightarrow s\gamma$ is summarized in [11]. Such corrections are almost completely known for the former decay mode.

Networking

Visiting scientists from or at other EURIDICE nodes:

- Henryk Czyż, Mikołaj Misiak, Leszek Łukaszuk, Maria Krawczyk participated in the first Collaboration Meeting in Frascati (18-20 October 2002).

- Maria Krawczyk visited Frascati (6-9.April 2003) to discussed with G. Pancheri various aspects of partonic content of the photon.

- Slawomir Wycech attended the Workshop on Chiral Dynamics, Valencia, June 25-29,2003 to give a seminar on eta-pion mixing and visited Barcelona 30-31 July to discuss with A.Ramos the physics of K mesons.

- Sławomir Wycech visited Helsinki in November 2003 to complete a joint publication on eta Helium bound state and eta pi mixing. A K-matrix analysis of eta-nucleon, pi-nucleon and gamma-nucleon S-wave interactions was initiated.

- Mikołaj Misiak visited U. of Zurich twice (February 9-15 2003 and July 3-20 2003) to give two seminars and work on a paper with D. Wyler and E. Lunghi on $B \rightarrow X_s l^+ l^-$. In July 2003, he also visited C. Greub at U. of Bern to discuss the ongoing $B \rightarrow X_s$ gamma calculation.

- Agnieszka Grzelińska visited twice University of Karlsruhe (only travel was paid by EURIDICE) (1st November 2002 - 15th December 2002 and 4th January - 31 January 2003) to work on upgrades of of PHOKHARA MC event generator.

- Agnieszka Grzelińska and Elżbieta Nowak participated in the VIII LNF Spring School in Nuclear, Subnuclear and Astroparticle Physics, which took place at INFN National Laboratories in Frascati, from 19th to 23th of May, 2003.

- Fernando Cornet from Granada visited Maria Krawczyk in 28.06 till 3.07.2003 to work on a new analysis of the parton densities in photon.

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Joint Publications

1. Numerical evaluation of the general massive 2-loop self-mass master integrals from differential equations, M. Caffo, H. Czyż and E. Remiddi, Nucl. Instrum. Meth. **A502**, 613 (2003) [hep-ph/0211171].
Katowice-Bolognia

2.THE RADIATIVE RETURN AT PHI- AND B-FACTORIES: FSR AT NEXT-TO- LEADING ORDER. Henryk Czyż, Agnieszka Grzelinska, Johann H. Kuhn, German Rodrigo (hep-ph/0308312), CERN-TH/2003-179, TTP03-22
Katowice-Karlsruhe-CERN

3. The radiative return at phi- and B-factories: small-angle photon emission at next to leading order Henryk Czyż, Agnieszka Grzelińska, Johann H. Kuhn, German Rodrigo (hep-ph/0212225) CERN-TH/2002-328, TTP02-43, Eur.Phys.J. C27 (2003) 563-575
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