Third Periodic Report

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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

Third Periodic Progress Report 01/09/2004 - 31/08/2005

Contents

1 A - RESEARCH RESULTS

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**
   - *To help clarify the origin of CP-violation*
   - *CP violation and rare decays*
   - *Quantum mechanics and the neutral meson system*
   - *To improve the theoretical precision for the CKM matrix elements*
2. **Chiral Perturbation Theory**
   - *To determine effective low-energy couplings from first principles*
   - *To investigate the order parameters of QCD*
   - *Baryon ChPT and Hypernuclei*
3. **Quark masses**
4. $\alpha_{em}(M_Z)$ **and the anomalous magnetic moment of the leptons**
   - $(g-2)_\mu$ *and multi-loop calculations*
   - *Precision determination of electroweak parameters*
   - *The electroweak contribution*
   - *Hadronic Effects in electroweak precision observables*
5. **Heavy flavour decays and Heavy Quark Effective Theory (HQET)**
   - *D-decays*
   - *B-decays*
6. **Strong Interaction limit of QCD**
   - α_s *in the infrared region*
   - *Meson and baryon Spectroscopy beyond the naive Quark Model*
   - *New mesons and baryons*

In the sections to follow, the progress achieved towards attainment of these objectives during the third operating period will be discussed. As one can see from the list of joint publications, where the KLOE collaboration papers appear, further progress was done by the experimental group KLOE, whose members in the network work in close collaboration with the theorists.

1.1 A1. Scientific Highlights

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

To help clarify the origin of CP-violation

- A new mechanism of leptogenesis in the context of supersymmetry has been proposed in which Susy breaking terms furnish i) a small mass splitting among the CP-even and the CP-odd right handed sneutrino states and ii) CP violation to generate leptogenesis.

CP violation and rare decays

- The Orsay group showed that two-body B decays with an axial-vector meson in the final state should have large branching ratios. In particular, the decay rates of $B \to K_1\pi$, $B \to a_1 K$ and $B \to b_1 K$ could be used to test the factorization ansatz.
- A new comprehensive analysis of the long-distance contributions to $K \to \pi\nu\bar{\nu}$ decays has been performed. From the numerical point of view, this analysis has allowed to decrease the irreducible theoretical error on the SM prediction of $B(K^+ \to \pi^+\nu\bar{\nu})$ below the 3% level.

Quantum mechanics and the neutral meson system

- In a joint project of Barcelona and Vienna, relevant aspects in testing Bell inequalities for entangled meson-antimeson systems were analysed. Entanglement or a possible loss of entanglement in the two-particle state can be tested by considering the decoherence of the state.
- The Vienna group has discussed the correspondence between the complementarity in wave interference and macroscopic thermodynamical quantities such as magnetization.

To improve the theoretical precision for the CKM matrix elements

- Intensive work for the Particle Data Group by members of INFN node has focused on a precise determination of the Cabibbo angle from semileptonic kaon decays, with examination of controversial experimental data (old PDG, new BNL, KTeV, NA48, istra, KLOE).
- The $\langle SPP \rangle$ Green function was investigated in a joint project of Valencia and Vienna. A number of chiral low-energy constants of $O(p^6)$ were determined, in particular the ones governing $SU(3)$ breaking in the K_{l3} vector form factor at $t = 0$. Implications for the extraction of V_{us} from K_{l3} decays were discussed.
- $|V_{us}|$ was estimated from hyperon semileptonic decays by the Valencia node.

1.1.2 Chiral Perturbation Theory

- Low energy $\pi\pi$ scattering

  The Bern node developed a method, based on non relativistic quantum field theory, to evaluate the amplitude for the decay $K \to 3\pi$ in a systematic expansion of $\pi\pi$ scattering lengths in a framework which allows a straightforward evaluation of radiative corrections to this process.

- In view of the precision measurement of the $\pi^0\pi^0$ invariant-mass spectrum in $K^+ \to \pi^+\pi^0\pi^0$ decays, the recently proposed method for the extraction of π–π scattering lengths from this observable has been rivisited by the INFN node and the theoretical error on the $a_0 - a_2$ combination extracted from the $K^+ \to \pi^+\pi^0\pi^0$ spectrum has been reduced to about 5%.

- Connection with Lattice calculations

  The Bern node performed a detailed numerical study of finite volume effects for masses and decay constants of the octet of pseudoscalar mesons, using chiral perturbation theory and asymptotic formulae *à la* Lüscher, and proposing an extension of the latter beyond the leading exponential term.

- The Lund group has calculated the masses and decay constants in partially quenched chiral perturbation theory to two-loop order as well as the decay constants in the three flavour case. This has been done for all possible mass cases. This is also relevant for determination of quark masses.

- A number of studies of algorithms for computing full QCD in lattice simulations have been performed by the DESY Zeuthen node. The primary aim is a deeper understanding of the chiral limit of lattice QCD.

- Bern and Helsinki nodes completed a full two-loop calculation of the neutral pion pair production in photon-photon collisions and computed the neutral pion polarizabilities.

- Axial-vector resonances were generated through the interaction of vector and pseudoscalar mesons (Valencia-Barcelona nodes).

- The generating functional for Green functions of quark currents was given in closed form to next-to-leading order for chiral $SU(3)$, including one-loop amplitudes with up to three meson propagators (Frascati/Vienna). A Mathematica program was constructed to calculate matrix elements and form factors for strong and nonleptonic weak processes with at most six external states.

- The spectra and decay widths of $\pi^\pm K^\mp$ atoms were worked out. The isospin-odd scattering length a_0^- is protected against contributions of m_s in the chiral expansion. The chiral two-loop representation for the πK amplitude was used to investigate the low–energy theorem for a_0^- at next-to-next-to-leading order in the SU(3) expansion (J. Schweizer, Vienna).

- The one loop renormalization of the Resonance Chiral Theory Lagrangian including one multiplet of scalar and pseudoscalar resonances was performed by the Valencia-Barcelona collaboration. item The full isospin breaking correction including radiative corrections for $K \to 3\pi$ have been calculated and compared with experiment by the Lund group.

To determine effective low-energy couplings from first principles

- Estimates for the $O(p^4)$ low-energy constants of chiral perturbation theory by means of a chiral Lagrangian with explicit vector, axial-vector, scalar and pseudoscalar resonance states were reanalysed. A resonance Lagrangian valid for a

large number of colours was considered where the η' particle is also present. The low-energy constants that are dominated by vector and axial-vector resonance contributions turn out to be insensitive to the presence of the η' (R. Kaiser, Vienna).

- The contribution of resonances to the $\mathcal{O}(p^6)$ Low Energy Couplings of Chiral Perturbation Theory was performed by the Valencia node.
- The Orsay group studied the chiral Lagrangian couplings describing radiative corrections to weak semi-leptonic decays. Sum rules for these couplings have been derived and evaluated using resonance saturation models. The resulting estimates for the low-energy couplings go beyond the usual $\log(M_Z/M_\rho)$ approximation.
- The Orsay group investigated some properties of the Resonance Chiral Theory, in two different settings : spin-1 correlators were considered in conjunction with sum rules to discriminate among various hadronic models for the resonance region, and the role of scalar resonances was highlited to interpret the quark-mass dependence of lattice results concerning pion and kaon decay constants.
- The leading order low energy couplings mediating kaon decays have been determined from first principles from the matching of lattice QCD with very light quarks with chiral perturbation theory in the epsilon-regime by the Valencia node.

To investigate the order parameters of QCD

- The Orsay node proposed a method to determine the flavour-dependence of chiral symmetry breaking through lattice simulations with dynamical fermions, using masses and decay constants of the pion and the kaon. The method exhibits only a mild sensitivity to finite-volume effects.

Baryon ChPT and Hypernuclei

- The study of the $\Lambda(1405)$ by the Valencia node has shown the existence of two states through the analysis of experimental data within the chiral unitary approach.
- Several realistic phenomenological nucleon-nucleon interaction models were rescaled by quark model relations to investigate the possibility of deuteron-like bound states of heavy flavor hyperons and nucleons. The Helsinki node found that bound states are likely to form between nucleons and the Ξ_c' and Ξ_{cc} charm hyperons as well as between Ξ hyperons and double-charm hyperons.
- It was shown by the Helsinki node that the the calculated E2/M1 ratio in gamma decay of the Delta(1232) resonance is closer to the empirical values in instant and point form kinematics than in front form kinematics in simple Poincare covariant quark models, which reproduce the empirical nucleon form factors.
- The K-matrix method was applied to the coupled ηN , πN, γN system, using the recent Crystal Ball data and the previous result, that the η-nucleon scattering length (a) is large with a value of $0.91(6)+i0.27(2)$ fm, is confirmed (Warsaw-Helsinki nodes).

- The Warsaw and Helsinki nodes extracted the η-π mixing angle $\theta = 0.6(3)^o$ using the K-matrix method which relates the amplitudes for $pd \to {}^3\mathrm{He}\eta$, $\pi^{+3}\mathrm{H} \to {}^3\mathrm{He}\eta$, $pd \to {}^3\mathrm{H}\pi^+$. With free parameters fitted to the data the existence of a virtual $\eta{}^3$He state and sizeable η-π mixing effects in the $pd \to {}^3\mathrm{He}\pi^0$ reaction was apparent.

1.1.3 Quark masses

- The Valencia group determined m_S and $|V_{us}|$ from hadronic tau decays.
- The Warsaw and DESY-Zeuthen nodes showed that the large logarithmic higher-order QCD corrections to the Higgs boson decay width into b-quarks, which are mapped into a running quark mass, can be consistently incorporated in the standard model radiative corrections.

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

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

- Progress was made also in the calculation of contributions to the Bhabha process at two–loops

Precision determination of electroweak parameters

- Further progress was made in calculating the full two-loop electroweak corrections to the effective leptonic weak mixing angle in the standard model
- Radiative corrections to the Higgs production at a linear e^+e^- collider have been calculated at the one–loop order in the double pole approximation including all tree level background diagrams (DESY Zeuthen-Warsaw).
- For leptonic tau decays the one-loop 2HDM(II) contributions to the branching ratios are calculated and an upper limit on M_{H^+} is obtained by the Warsaw node.

Hadronic Effects in electroweak precision observables

- One of the highlights of the joint INFN-DESY Zeuthen and Warsaw collaboration is the final measurement of $\sigma(e^+e^- \to \pi^+\pi^-\gamma)$ and extraction of $\sigma(e^+e^- \to \pi^+\pi^-)$ below 1 GeV with the KLOE detector.
- joint DESY Zeuthen-Warsaw collaboration showed that charge asymmetry gives a unique signal for the interference between the amplitude for $\pi\pi$ production through the radiative return method and $\pi\pi$ production from the radiative ϕ-decay. It was demonstrated that the impact of radiative ϕ-decays on the measurement of the pion form factor can be kept well under control, if suitable kinematic regions are selected.

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

- The Helsinki node has succeeded in extracting reasonable estimates for the P-wave and (to a lesser extent) D-wave charge distributions of heavy-light mesons in lattice QCD. A large vector confining potential is needed to explain the data.

D-decays

- The UK team has analyzed the decay of charmed mesons D, D_s to both light hadrons and leptons and the implications of these for both the Standard Model and our understanding of strong final state interactions.

B-decays

- The Bern node made considerable progress in the calculation of the order α_s^2 corrections to the matrix elements for $B \to X_s\gamma$ associated with the operator O_7.
- A calculation of the complete three-loop $O(\alpha_s^3)$ anomalous dimension matrix for dimension-five dipole operators (that arise in the Standard Model after integrating out the top quark and the heavy electroweak bosons) which represents an important ingredient of the next-to-next-to-leading order QCD analysis of the $B \to X_s\gamma$ decay was performed by the Warsaw node.
- It was demonstrated that the sign of the $b \to s\gamma$ amplitude can be determined from the current data on $b \to sl^+l^-$ (Warsaw node).
- The flavour-changing electromagnetic dipole operator O_7 gives the dominant contribution to the $B \to Xs\gamma$ decay rate. Two-loop QCD corrections to its matrix element are calculated together with the corresponding bremsstrahlung contributions by Warsaw node. The complete result is used to test the validity of the naive non-abelianization (NNA) approximation that has been previously applied to estimate the NNLO QCD correction to $\Gamma(B \to Xs\gamma)/\Gamma(B \to Xue\nu)$.
- A novel analysis of B decays to two light pseudoscalar mesons has been performed by the CNRS DR12 node in Marseille, using a model-independent approach in the SU(3)-flavor limit.
- A systematic study of Bjorken-like sum rules in the heavy-quark limit of QCD has been performed including non-leading contributions in $1/M_Q$. The form factors obtained from the perturbation of the heavy-quark Lagrangian were considered. Phenomenological implications for $B \to D^{**}\pi$ decays were considered.
- The Lund/Oslo group has studied colour supressed contributions in B_d and B_s decays to pairs of D and D^* mesons.

1.1.6 Strong Interaction limit of QCD

- The DESY-Zeuthen- Warsaw has shown how the models of radiative ϕ*decays* ($\phi \to (f_0(980) + \sigma(600)) + \gamma \to \pi\pi\gamma$) can be tested at KLOE, giving valuable information on the poorly known scalar ($f_0(980), \sigma(600)$) interactions.

α_s in the infrared region

- In a joint INFN/LNF and Barcelona/Granada collaboration, further studies of the infrared limit of α_s have focused on the dependence of the total cross-section at LHC from this behaviour

Meson and baryon Spectroscopy beyond the naive Quark Model

- The Helsinki node has worked on interpreting the experimental evidence for the lightest scalar nonet ($\sigma(600)$, $\kappa(800)$, $a_0(980)$, $f_0(980)$), and in particular on their relevance for chiral symmetry breaking.

New mesons and baryons

- The UK team has started a thorough study of the new hadronic states, both mesons and baryons, that have been discovered in a series of experiments at BaBar, Belle, Fermilab and JLAB, focusing on the interpretation of these states and their relation to QCD dynamics.

1.2 A.2 Joint Publications and Young Researcher Publications

In the following we list the joint publications by the network participants, in order of participant number. We distinguish between papers published in refereed journals, conference proceedings and preprints. 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**. 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

1. V.K. Magas, E. Oset and A. Ramos, *Evidence for the two-pole structure of the $\Lambda(1405)$ resonance*, Phys. Rev. Lett. **95** (2005) 052301. **Valencia-Barcelona**

2. E. Gámiz, M. Jamin, A. Pich, J. Prades and F. Schwab, *V_{us} and m_s from hadronic τ decays*, Phys. Rev. Lett. **94** (2005) 011803. **Valencia-Barcelona/Granada**

3. A. Bramon, R. Escribano and G. Garbarino, *Bell's inequality tests with meson-antimeson pairs*, J. Mod. Opt. **52** (2005) 1681-1684 [quant-ph/0501069]. **INFN/Turin-Barcelona**

4. W.M. Alberico, G. Garbarino, A. Parreno and A. Ramos, *Asymmetries in the non-mesonic weak decay of polarized Λ-hypernuclei*, Phys. Rev. Lett. **94** (2005) 082501 [nucl-th/0410107]. **INFN/Turin-Barcelona**

5. R.A. Bertlmann, A. Bramon, G. Garbarino and B.C. Hiesmayr, *Violation of a Bell inequality in particle physics experimentally verified?*, Phys. Lett. **A332** (2004) 355-360 [quant-ph/0409051]. **INFN/Turin-Barcelona-Vienna**

6. A.M. Green and S. Wycech, *η-Nucleon scattering length and effective range uncertainties*, Phys. Rev. **C71** (2005) 014001 [nucl-th/0411024]. **Helsinki-Warsaw**

7. H. Czyz, A. Grzelinska and J.H. Kühn, *Charge asymmetry and radiative ϕ decays*, Phys. Lett. **B611** (2005) 116 [hep-ph/0412239]. **DESY Zeuthen/Karlsruhe-Warsaw/Katowice**

8. H. Czyz, A. Grzelinska, J.H. Kühn and G. Rodrigo, *The radiative return at ϕ- and B-factories: FSR for muon pair production at next-to-leading order*, Eur. Phys. J. **C39** (2005) 411 [hep-ph/0404078]. **Warsaw/Katowice-DESY Zeuthen/Karlsruhe-Valencia**

9. F. Cornet, P. Jankowski and M. Krawczyk, *CJK-improved 5 flavour LO parton distributions in the real photon*, Acta Phys. Polon. **B35** (2004) 2215 (September 2004) [hep-ph/0404244]. **Warsaw-Barcelona/Granada**

10. F. Cornet, P. Jankowski and M. Krawczyk, *A new 5 flavour NLO analysis and parametrizations of parton distributions of the real photon*, Phys. Rev. **D70** (2004) 093004 [hep-ph/0404063]. **Warsaw-Barcelona/Granada**

11. V. Cirigliano, G. Ecker, M. Eidemüller, R. Kaiser, A. Pich and J. Portolés, *The $\langle SPP \rangle$ Green function and SU(3) breaking in K_{l3} decays*, JHEP **0504** (2005) 006. **Valencia-Vienna**

12. J. Gasser, B. Kubis, N. Paver and M. Verbeni, *Radiative K_{e3} decays revisited*, Eur. Phys. J. **C40** (2005) 205-227 [hep-ph/0412130]. **Bern-INFN/Trieste-Barcelona/Granada**

13. S. Dürr and Ch. Hoelbling, *Scaling tests with dynamical overlap and rooted staggered fermions*, Phys. Rev. **D71** (2005) 054501 [hep-lat/0411022]. **DESY Zeuthen-Bern-Marseille**

14. F. Ambrosino *et al.* [KLOE Collaboration], *Data handling, reconstruction, and simulation for the KLOE experiment*, Nucl. Instrum. Meth. **A534** (2004) 403. **INFN-DESY Zeuthen/Karlsruhe**

15. A. Aloisio *et al.* [KLOE Collaboration], *Measurement of $\sigma(e^+e^- \to \pi^+\pi^-\gamma)$ and extraction of $\sigma(e^+e^- \to \pi^+\pi^-)$ below 1 GeV with the KLOE detector*, Phys. Lett. **B606** (2005) 12. **INFN-DESY Zeuthen/Karlsruhe**

16. F. Ambrosino *et al.* [KLOE Collaboration], *Upper limit on the $\eta \to \pi^+\pi^-$ branching ratio with the KLOE detector*, Phys. Lett. **B606** (2005) 276. **INFN-DESY Zeuthen/Karlsruhe**

17. F. Ambrosino *et al.* [KLOE Collaboration], *Measurement of the leptonic decay widths of the ϕ-meson with the KLOE detector*, Phys. Lett. **B608** (2005) 199 [hep-ex/0411082]. **INFN-DESY Zeuthen/Karlsruhe**

18. F. Ambrosino *et al.* [KLOE Collaboration], *A direct search for the CP-violating decay $K_S \to \pi^0\pi^0\pi^0$ with the KLOE detector at DAPHNE*, Phys. Lett. **B619** (2005) 61 [hep-ex/0505012]. **INFN-DESY Zeuthen/Karlsruhe**

19. G. Nardulli and T.N. Pham, *$B \to K_1\gamma$ and test of factorization for two-body non-leptonic B decays with axial-vector mesons*, Phys. Lett. **B623** (2005) 65 [hep-ph/0505048]. **INFN-Orsay**

20. J. Hirn and J. Stern, *Anomaly-matching and Higgs-less effective theories*, JHEP **0409** (2004) 058 (October 2004) [hep-ph/0403017]. **Durham-Orsay**

1.2.2 Conference Proceedings

1. G. Pancheri, R.M. Godbole, A. Grau and Y.N. Srivastava, *Aspects of confinement in total cross sections through Bloch-Nordsieck soft gluon summation*, Nucl. Phys. Proc. Suppl. **146** (2005) 177-181. **INFN-Barcelona/Granada**

2. G. Pancheri, A. De Roeck, R.M. Godbole, A. Grau and Y.N. Srivastava, *Total cross-sections: Cross-talk between HERA, LHC and LC*, Presented at Paris Workshop on International Linear Collider [hep-ph/0412189]. **INFN-Barcelona/Granada**

3. G. Pancheri, R.M. Godbole, A. Grau and Y.N. Srivastava, *Total cross-sections and Bloch-Nordsieck gluon resummation*, Acta Phys. Polon. **B36** (2005) 735-742 [hep-ph/0411006]. **INFN-Barcelona/Granada**

4. A. Ramos, E. Oset, C. Bennhold, D. Jido, J.A. Oller and U.G. Meissner, *Dynamical generation of hyperon resonances*, Nucl. Phys. **A754** (2005) 202-211. **Valencia-Barcelona**

5. D. Jido, J.A. Oller, E. Oset, A. Ramos and U.G. Meissner, *Structure of $\Lambda(1405)$ and chiral dynamics*, Nucl. Phys. **A755** (2005) 669-672. **Valencia-Barcelona**

6. E. Gamiz, M. Jamin, A. Pich, J. Prades and F. Schwab, *Determination of $|V_{us}|$ from hadronic τ decays*, Invited talk at the 40th Rencontres de Moriond on Electroweak Interactions and Unified Theories, La Thuile, Aosta Valley, Italy, 5-12 March 2005 [hep-ph/0505122]. **Valencia-Barcelona**

7. E. Oset, D. Cabrera, V.K. Magas, L. Roca, S. Sarkar, M.J. Vicente Vacas and A. Ramos, *Chiral dynamics of baryon resonances and hadrons in a nuclear medium*, Lectures given at the Workshop on Hadron Physics, Puri, India, 7-17 March 2005, submitted to Pramana [nucl-th/0504033]. **Valencia-Barcelona**

8. A. Ramos, C. Bennhold, A. Hosaka, T. Hyodo, D. Jido, U.G. Meissner, J.A. Oller, E. Oset and M.J. Vicente Vacas, *Dynamical baryon resonances from chiral unitarity*, to appear in the proceedings of Workshop on the Physics of Excited Nucleons (NSTAR 2004), Grenoble, France, 24-27 March 2004 [nucl-th/0502053]. **Valencia-Barcelona**

9. E. Oset, D. Cabrera, V.K. Magas, L. Roca, M.J. Vicente Vacas, A. Ramos, T. Inoue, C. Garcia Recio and J. Nieves, *Chiral dynamics of hadrons in nuclei*, Invited talk at the Workshop on In-Medium Hadron Physics, Giessen, Germany, 11-13 Nov 2004, submitted to Acta Phys. Hung. [nucl-th/0501059]. **Valencia-Barcelona**

10. E. Oset, S. Sarkar, M.J. Vicente Vacas, A. Ramos, D. Jido, J.A. Oller and U.G. Meissner, *Dynamically generated resonances in the chiral unitary approach to meson baryon interaction*, Talk given at the 10th International Symposium on Meson-Nucleon Physics and the Structure of the Nucleon (MENU 2004), Beijing, China, 29 Aug - 4 Sept 2004, Int. J. Mod. Phys. **A20** (2005) 1619-1626. **Valencia-Barcelona**

11. E. Gamiz, M. Jamin, A. Pich, J. Prades and F. Schwab, *Extraction of m_s and $|V_{us}|$ from hadronic tau decays*, Invited talk at the 8th International Workshop on Tau Lepton Physics (Tau04), Nara, Japan, 14-17 Sept 2004, Nucl. Phys. Proc. Suppl. **144** (2005) 59-64. **Valencia-Barcelona/Granada**

12. L. Giusti, P. Hernández, M. Laine, C. Pena, P. Weisz, J. Wennekers and H. Wittig, *Correlation functions at small quark masses with overlap fermions*, Talk given at the 22nd International Symposium on Lattice Field Theory (Lattice 2004), 21-26 June 2004, Nucl. Phys. Proc. Suppl. **140** (2005) 417-419. **Valencia-Marseille**

13. V. Giménez, V. Lubicz, F. Mescia, V. Porretti and J. Reyes, *Operator product expansion and quark condensate from lattice QCD in coordinate space*, Eur. Phys. J. **C41** (2005) 535-544. **Valencia-INFN**

14. K.-I. Nagai, K. Jansen, W. Bietenholz, L. Scorzato, S. Necco and S. Shcheredin, *Testing topology conserving gauge actions for lattice QCD*, Proc. Sci. LAT2005 (2005) 283. **Marseille - DESY Zeuthen**

15. W. Bietenholz, K. Jansen, K.-I. Nagai, S. Necco, L. Scorzato and S. Shcheredin [XLF Collaboration], *Lattice gauge actions for fixed topology*, Talk given at the 6th Conference on Quark Confinement and the Hadron Spectrum, Villasimius, Sardinia, Italy, 21-25 Sept 2004, Published in AIP Conf. Proc. **756** (2005) 248-250 [hep-lat/0412017]. **Marseille - DESY Zeuthen**

16. M. Verbeni, J. Gasser, B. Kubis and N. Paver, *Comments on radiative K(l3) decays*, Int. J. Mod. Phys. **A20** (2005) 465-471. **Bern-INFN/Trieste-Barcelona/Granada**

17. S. Wycech and A.M. Green, *K-matrix analysis of* $^3He-\eta$ *system and* $\eta-\pi^0$ *mixing*, Int. J. Mod. Phys. **A20** (2005) 637. **Helsinki-Warsaw**

18. J. Hirn and J. Stern, *Higgs-less Higgs mechanism: low-energy expansion*, to appear in the proceedings of the 40th Rencontres de Moriond on Electroweak Interactions and Unified Theories, La Thuile, Aosta Valley, Italy, 5-12 March 2005 [hep-ph/0507222]. **Valencia-Orsay**

19. F. Jegerlehner, K. Kolodziej and T. Westwanski, *Towards precise predictions for the Higgsstrahlung at a linear collider*, Presented at 7th DESY Workshop on Elementary Particle Theory: Loops and Legs in Quantum Field Theory, Zinnowitz, Germany, 25-30 April 2004, Nucl. Phys. Proc. Suppl. **135** (2004) 92 (October 2004) [hep-ph/0407071]. **Warsaw/Katowice-DESY/Zeuthen**

20. S. Dürr, Ch. Hoelbling, U. Wenger, *A comparative study of overlap and staggered fermions in QCD*, Proc. Lattice 2004 [hep-lat/0409108]. **DESY Zeuthen-Bern-Marseille**

21. W. Kluge, *The reaction* $\sigma(e^+e^-\to\pi^+\pi^-)$ *and its relation to the anomalous magnetic moment of the muon*, Proc. Int. Conf. on Hadron Structure 2004, HS 2004, Smolenice, Slovakia, 30 Aug - 3 Sept 2004, Acta Phys. Slov. **55** (2005) 49. **INFN-DESY Zeuthen/Karlsruhe**

22. D. Leone for the KLOE collaboration, *Measurement of the hadronic cross section* $\sigma(e^+e^-\to\pi^+\pi^-\gamma)$ *with KLOE*, Proc. Int. Workshop on Tau Lepton Physics Tau04, Nara, Japan, 14-17 Sept 2004, Nucl. Phys. Proc. Suppl. **144** (2005) 231. **INFN-DESY Zeuthen/Karlsruhe**

23. A.G. Denig *et al.* [KLOE Collaboration], *Measurement of the hadronic cross section via radiative return at DA*Φ*NE*, Proc. 10^{th} Int. Symposium on Meson-Nucleon Physics and the Structure of the Nucleon, MENU 2004, Beijing, 29 August - 4 Sept 2004, Int. J. Mod. Phys. **A20** (2005) 1935. **INFN-DESY Zeuthen/Karlsruhe**

24. S.E. Müller [KLOE Collaboration], *KLOE results at the Frascati ϕ-factory DAΦNE*, Proc. 10^{th} Int. Symposium on Meson-Nucleon Physics and the Structure of the Nucleon, MENU 2004, Beijing, 29 August - 4 Sept 2004, Int. J. Mod. Phys. **A20** (2005) 1888. **INFN-DESY Zeuthen/Karlsruhe**

25. D. Leone for the KLOE Collaboration, *Results with radiative events at KLOE*, Proc. Internat. Europhys. Conf. on High Energy Physics EPS, Lisbon, 21-27 July 2005. **INFN-DESY Zeuthen/Karlsruhe**

1.2.3 Preprints

1. F. Ambrosino *et al.* [KLOE Collaboration], *Measurement of the K_L meson lifetime with the KLOE detector*, accepted by Phys. Lett. **B** [hep-ex/0507088]. **INFN-DESY Zeuthen/Karlsruhe**

2. F. Ambrosino *et al.* [KLOE Collaboration], *Measurements of the absolute branching ratios for the dominant K_L decays, the K_L lifetime, and V_{us} with the KLOE detector*, submitted to Phys. Lett. **B** [hep-ex/0508027]. **INFN-DESY Zeuthen/Karlsruhe**

3. J. Hirn and J. Stern, *Lepton-number violation and right-handed neutrinos in Higgs-less effective theories* [hep-ph/0504277]. **Valencia-Orsay**

4. J. Hirn and V. Sanz, *Interpolating between low and high energy QCD via a 5-D Yang-Mills Model* [hep-ph/0507049]. **Valencia-Barcelona/Granada**

5. J.A. Oller, J. Prades and M. Verbeni, *Surprises in threshold antikaon-nucleon physics*, Phys. Rev. Lett. (in print) [hep-ph/0508081]. **Valencia-Barcelona/Granada**

6. A. Bramon, R. Escribano and G. Garbarino, *Bell's inequality tests: From photons to B-mesons* [quant-ph/0410122]. **INFN/Turin-Barcelona**

7. J. Prades, J. Bijnens and E. Gamiz, *The B(K) kaon parameter in the 1/N(c) expansion* [hep-ph/0501177]. **Barcelona/Granada-Lund**

8. S. Wycech and A.M Green, *On the nuclear states of K^- mesons* [nucl-th/0501019]. **Helsinki-Warsaw**

9. F. Jegerlehner, K. Kołodziej and T. Westwanski, *One-loop electroweak factorizable corrections for the Higgsstrahlung at a linear collider*, Eur. Phys. J. **C** (accepted for publication) [hep-ph/0503169]. **DESY Zeuthen-Warsaw**

10. S. Dürr, C. Hoelbling and U. Wenger, *Filtered overlap: Speedup, locality, kernel non-normality and Z(A) approx.1* [hep-lat/0506027]. **DESY Zeuthen-Bern**

11. R. Unterdorfer and G. Ecker, *Generating functional for strong and nonleptonic weak interactions* [hep-ph/0507173]. **INFN/Frascati-Vienna**

12. S. Shcheredin, W. Bietenholz, K. Jansen, K. I. Nagai, S. Necco and L. Scorzato, *Testing a topology conserving gauge action in QCD* [hep-lat/0409073]. **DESY Zeuthen-Marseille**

13. M. Gorbahn, U. Haisch and M. Misiak, *Three-loop mixing of dipole operators*, Phys. Rev. Lett. **95** (2005) 102004 (September 2005) [hep-ph/0504194]. **Warsaw-Durham**

14. J. Gasser, M.A. Ivanov and M.E. Sainio, *Low-energy photon-photon collisions to two loops revisited*, Nucl. Phys. **B728** (2005) 31 [hep-ph/0506265]. **Bern-Helsinki**

15. M. Cannoni, C. Carimalo, W. Da Silva and O. Panella, *Testing SUSY models of lepton-flavor violation at a photon collider* [hep-ph/0508256]. **INFN-Orsay**

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.

Christopher Smith : INFN-LNF

- G. Isidori, F. Mescia and C. Smith, *Light quark loops in* $K \to \pi\nu\bar{\nu}$, Nucl. Phys. **B718** (2005) 319-338 [hep-ph/0503107].
- C. Smith, *Long Distance Effects in rare K-decays*, Talk given at the 40th Rencontres de Moriond on Electroweak Interactions and Unified Theories, La Thuile, Aosta Valley, Italy, 5-12 March 2005 [hep-ph/0505163].
- J.-M. Gérard, C. Smith and S. Trine, *Radiative Kaon Decays and the Penguin Contribution to the* $\Delta I = 1/2$ *Rule*, Nucl. Phys. **B** (in print) [hep-ph/0508189].

Stéphanie Trine : INFN-LNF

- S. Trine, *Strong and electromagnetic anomalies in weak meson decays*, UCL thesis catalogue Dec 2004.
- J.-M. Gérard, C. Smith and S. Trine, *Radiative Kaon Decays and the Penguin Contribution to the* $\Delta I = 1/2$ *Rule*, Nucl. Phys. **B** (in print) [hep-ph/0508189].

Johannes Hirn : University of Valencia

- J. Hirn and J. Stern, *Lepton-number violation and right-handed neutrinos in Higgs-less effective theories* [hep-ph/0504277].
- J. Hirn and J. Stern, *Higgs-less Higgs mechanism: low-energy expansion*, to appear in the proceedings of the 40th Rencontres de Moriond on Electroweak Interactions and Unified Theories, La Thuile, Aosta Valley, Italy, 5-12 March 2005 [hep-ph/0507222].
- J. Hirn and V. Sanz, *Interpolating between low and high energy QCD via a 5-D Yang-Mills Model* [hep-ph/0507049].

Ignazio Scimemi: Universitat de Barcelona

- E. Gamiz, J. Prades and I. Scimemi, *Charged kaon $K \to 3\pi$ CP violating asymmetries*, In Proceedings of Beijing 2004, ICHEP 2004, Vol. 2 pag. 805 [hep-ph/0410150].

Michela Verbeni: UAB - Universidad de Granada

- Jose A. Oller, J. Prades and M. Verbeni, *Surprises in threshold antikaon-nucleon physics*, Phys. Rev. Lett. (in print) [hep-ph/0508081].
- M. Verbeni, J. Gasser, B. Kubis and N. Paver, *Comments on radiative K(l3) decays*, Int. J. Mod. Phys. **A20** (2005) 465-471.
- J. Gasser, B. Kubis, N. Paver and M. Verbeni, *Radiative K_{e3} decays revisited*, Eur. Phys. J. **C40** (2005) 205-227 [hep-ph/0412130].

Silvia Necco : CNRS-CPT Marseille

- K.-I. Nagai, K. Jansen, W. Bietenholz, L. Scorzato, S. Necco and S. Shcheredin, *Testing topology conserving gauge actions for lattice QCD*, Proc. Sci. LAT2005 (2005) 283.
- W. Bietenholz, K. Jansen, K.-I. Nagai, S. Necco, L. Scorzato and S. Shcheredin [XLF Collaboration], *Lattice gauge actions for fixed topology*, Talk given at the 6th Conference on Quark Confinement and the Hadron Spectrum, Villasimius, Sardinia, Italy, 21-25 Sep. 2004, Published in AIP Conf. Proc. **756** (2005) 248-250 [hep-lat/0412017].
- M. Hasenbusch and S. Necco, *SU(3) lattice gauge theory with a mixed fundamental and adjoint plaquette action: Lattice artefacts*, JHEP **0408** (2004) 005 [hep-lat/0405012].
- S. Necco and R. Sommer, *Evaluation of glueball masses from lattice gauge theories and scaling behavior*, prepared for NIC Symposium 2004, Julich, Germany, 17-18 Feb 2004, Published in "Juelich 2004, NIC symposium 2004" 159-168.

Juan José Sanz-Cillero: CNRS-IN2P3 Orsay-Paris

- J.J. Sanz-Cillero, *Pion and Kaon decay constants: lattice versus resonance chiral theory*, Phys. Rev. **D70** (2004) 094033 [hep-ph/0408080].
- J.J. Sanz-Cillero, *Spin-1 correlators at large N_c: matching OPE and resonance theory up to $O(\alpha_s)$* [hep-ph/0507186].

Laura Edera : University of Durham

- J.M. Link, L. Edera *et al.* [FOCUS Collaboration], *Study of the $D^0 \to K^+K^-\pi^+\pi^-$ decay*, Phys. Lett. **B610** (2005) 225 [hep-ex/0411031].

- J.M. Link, L. Edera *et al.* [FOCUS Collaboration], *Measurement of the doubly Cabibbo suppressed decay $D^0 \to K^+\pi^-$ and a search for charm mixing*, Phys. Lett. **B618** (2005) 23 [hep-ex/0412034].

- J.M. Link, L. Edera *et al.* [FOCUS Collaboration], *Hadronic mass spectrum analysis of $D^+ \to K^-\pi^+\mu^+\nu$ decay and measurement of the $K^*(892)^0$ mass and width*, Phys. Lett. **B621** (2005) 72 [hep-ex/0503043].

- J.M. Link, L. Edera *et al.* [FOCUS Collaboration], *Study of Λ_c^+ Cabibbo favored decays containing a Λ baryon in the final state*, Phys. Lett. **B624** (2005) 22 [hep-ex/0505077].

- J.M. Link, L. Edera *et al.* [FOCUS Collaboration], *Search for T violation in charm meson decays*, Phys. Lett. **B622** (2005) 239 [hep-ex/0506012].

- J.M. Link, L. Edera *et al.* [FOCUS Collaboration], *Search for a strongly decaying neutral charmed pentaquark*, Phys. Lett. **B622** (2005) 229 [hep-ex/0506013].

- L. Edera, *Study of the doubly and singly Cabibbo suppressed decays $D^+ \to K^+\pi^-\pi^+$ and $D_s^+ \to K^+\pi^-\pi^+$ in the FOCUS experiment*, FERMILAB-THESIS-2005-26.

- L. Edera and M.R. Pennington, *Estimating the $I = 3/2$ $K\pi$ interaction in D decay*, Phys. Lett. **B623** (2005) 55 [hep-ph/0506117].

Timo Lähde : University of Lund

- J. Bijnens, N. Danielsson and T.A. Lähde, *The Pseudoscalar Meson Mass to Two Loops in Three-Flavor Partially Quenched χPT*, Phys. Rev. **D70** (2004) 111503 [hep-lat/0406017].

- J. Bijnens and T.A. Lähde, *Decay constants of pseudoscalar mesons to two loops in three-flavor partially quenched χPT*, Phys. Rev. **D71** (2005) 094502 [hep-lat/0501014].

- J. Bijnens and T.A. Lähde, *Masses and decay constants of pseudoscalar mesons to two loops in two-flavor partially quenched chiral perturbation theory* [hep-lat/0506004].

Bruno Julia-Diaz : UH.DPHY University of Helsinki

- J. He, B. Julia-Diaz and Y.-B. Dong, *Electroweak properties of the pi, K and K*(892) in the three forms of relativistic kinematics*, Eur. Phys. J. **A24** (2005) 411 [hep-ph/0503294].

- B. Julia-Diaz and D.O. Riska, *D-state configurations in the electromagnetic form factors of the nucleon and the $\Delta(1232)$ resonance*, Nucl. Phys. **A757** (2005) 441 [nucl-th/0411012].
- F. Frömel, B. Julia-Diaz and D.O. Riska, *Bound states of double flavor hyperons*, Nucl. Phys. **A750** (2005) 337 [nucl-th/0410034].
- J. He, B. Julia-Diaz and Y.-B. Dong, *Electromagnetic form factors of pion and rho in the three forms of relativistic kinematics*, Phys. Lett. **B602** (2004) 212 [hep-ph/0407043].
- B. Julia-Diaz, D.O. Riska and F. Coester, *Axial transition form factors and pion decay of baryon resonances*, Phys. Rev. **C70** (2004) 045204 [nucl-th/0406015].
- B. Julia-Diaz and D.O. Riska, *Nuclei of double-charm hyperons*, Nucl. Phys. **A755** (2005) 431c [nucl-th/0405061].
- B. Julia-Diaz, A. Valcarce and F. Fernandez, *The p(d,d') reaction and the sigma N N*(1440) coupling constant*, Fizika **B13** (2004) 347 [nucl-th/0308086].

Michal Czakon : DESY Zeuthen

- M. Czakon, J. Gluza and T. Riemann, *Master integrals for massive two-loop Bhabha scattering in QED*, Phys. Rev. **D71** (2005) 073009 [hep-ph/0412164].
- M. Czakon, *The four-loop QCD beta-function and anomalous dimensions*, Nucl. Phys. **B710** (2005) 485 [hep-ph/0411261].
- M. Awramik, M. Czakon, A. Freitas and G. Weiglein, *Towards better constraints on the Higgs boson mass: Two-loop fermionic corrections to* $\sin^2(\Theta)^{\rm lept}_{\rm eff}$ [hep-ph/0409142].
- M. Czakon, J. Gluza and T. Riemann, *On master integrals for two loop Bhabha scattering* [hep-ph/0409017].

Roland Kaiser : University of Vienna

- R. Kaiser, *Large N_c in chiral resonance Lagrangians*, to be published in Proc. of the ECT* Workshop on Large N_c QCD, Trento, Italy, July 2004 [hep-ph/0503108].
- V. Cirigliano, G. Ecker, M. Eidemuller, R. Kaiser, A. Pich and J. Portolés, *The $\langle SPP\rangle$ Green function and SU(3) breaking in K_{l3} decays*, JHEP **0504** (2005) 006.

Julia Schweizer : University of Vienna

- J. Schweizer, *Spectrum and decays of hadronic atoms*, Int. J. Mod. Phys. **A20** (2005) 358.
- J. Schweizer, *Isospin odd πK scattering length*, Phys. Lett. **B** (in print) [hep-ph/0507323].

2 B - COMPARISON WITH THE PROJECT PROGRAM

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 Methodological Approach and Work Plan

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 a $\star$ to indicate the assigned tasks at the time of the Contract, we have included

a $\surd$ to indicate the involvement of the groups during the first year of operation (see First Periodic Report),

a $\bullet$ for the involvement during the second year of operation (see Second Periodic Report),

a $\oplus$ for involvement at the time of this report.

Notice that, with respect to the contract, the last two columns in Table 2 have been re-labelled so as to include a number of items related to the given task. Thus, the column α_s *in the infrared* includes now also *Structure functions* and *total cross-sections*, whereas *glueballs spectroscopy* includes the study of scalar mesons and the newly observed exotic quarkonia. From these tables one can see that most groups are actually performing the tasks as originally planned. Further updates and completions of tasks can be expected as the project moves toward completion.

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

Team	Quark masses	ChPT 3 flav ours	Isospin breaking effects	Large N_c QCD	N_f/N_c dependence	Lattice QCD and and ChPT	HQET and LEET	EFT in Nuclear matter
INFN		$\oplus$	$\star$	$\oplus$		$\oplus$	$\star\surd\bullet\oplus$	$\star\bullet\oplus$
UVEG	$\star\surd\bullet\oplus$	$\star\oplus$	$\star\surd\bullet$	$\star\surd\bullet\oplus$		$\star\bullet$	$\star$	$\star\surd$
UAB		$\star\surd\bullet$		$\star\surd\bullet$	$\star\bullet$			
CNRS DR12		$\star$	$\star$	$\star\bullet\oplus$		$\star\surd\bullet\oplus$	$\star$	
CNRS-IN2P3	$\star\bullet$	$\star\surd\bullet\oplus$	$\star\bullet\oplus$	$\star\oplus$	$\star\ \surd$		$\star\ \surd\bullet\oplus$	
DUR	$\bullet\oplus\ \star$		$\star$					$\star\oplus$
ULUND	$\star\surd\bullet\oplus$	$\star\surd\bullet\oplus$	$\star\bullet\oplus$	$\star\surd\bullet\oplus$		$\star\surd\bullet\oplus$	$\surd\bullet\oplus$	
UHELS	$\star\bullet$	$\star\bullet\oplus$	$\star\bullet\oplus$	$\surd\bullet\oplus$		$\surd$		
DESY Zeuthen	$\star\bullet\oplus$		$\star\bullet\oplus$			$\star\surd\bullet\oplus$		
UNIBE	$\star\bullet\oplus$	$\star\surd\bullet\oplus$	$\star\surd\bullet$	$\star$		$\surd\bullet\oplus$	$\star\bullet\oplus$	
Vienna	$\surd\bullet\oplus$	$\star\surd\bullet\oplus$	$\star\surd\bullet\oplus$	$\surd\bullet\oplus$				
Warsaw		$\star$	$\star$					

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 structure functions σ_{total}	glueballs scalars exotics and spectro scopy
INFN	$\star\surd\bullet\oplus$	$\star\surd\bullet\oplus$	$\star\surd\bullet\oplus$	$\star\surd\bullet\oplus$	$\star\surd\bullet$	$\star\surd\bullet\oplus$	$\bullet$
UVEG	$\star\surd\bullet\oplus$	$\star\surd\bullet\oplus$	$\star$	$\star\surd\oplus$	$\star\surd$		$\bullet\oplus$
UAB	$\star\surd\bullet$	$\star\bullet\ \surd$	$\star\oplus$	$\star\surd\bullet$	$\surd\bullet$	$\surd\oplus$	$\bullet$
CNRS DR12	$\star\surd\bullet\oplus$	$\star\surd\bullet\oplus$	$\star\surd\bullet\oplus$	$\star\surd$	$\star\surd\bullet\oplus$		$\bullet$
CNRS-IN2P3	$\star\surd\bullet\oplus$	$\star\surd\bullet\oplus$	$\star\oplus$	$\star\surd\bullet\oplus$			
DUR				$\star\surd\bullet\oplus$	$\star$	$\star\bullet\oplus$	$\star\surd\bullet\oplus$
ULUND	$\star\surd\bullet\oplus$	$\star\surd$	$\star\oplus$	$\star\surd\bullet\oplus$			
UHELS				$\star\surd\bullet\oplus$			$\star\surd\bullet\oplus$
DESY Zeuthen					$\star\surd\bullet$		
UNIBE	$\star\surd\bullet\oplus$	$\star\surd\bullet\oplus$	$\star\surd\bullet\oplus$	$\star\surd\bullet$	$\star\surd\bullet\oplus$		
Vienna	$\star\surd\bullet\oplus$	$\star\surd\bullet\oplus$	$\star\bullet$		$\star$		
Warsaw	$\star\surd$	$\surd$	$\star$	$\star\surd\bullet\oplus$	$\star\surd\bullet\oplus$	$\bullet\oplus$	$\star\oplus$

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	$\star\oplus$	$\bullet\oplus$	$\star\bullet\oplus$		$\star\oplus$	$\star\bullet\oplus$
UVEG			$\bullet\oplus$	$\star\surd\bullet\oplus$	$\star\surd\bullet\oplus$	$\star\surd\oplus$
UAB		$\star\oplus$		$\star$	$\star\bullet$	$\star\surd\bullet$
CNRS DR12	$\star$	$\star$		$\star$		
CNRS-IN2P3	$\star\oplus$	$\star$		$\star\oplus$		
DUR				$\star\surd\bullet\oplus$	$\star\bullet\oplus$	$\star\surd\bullet\oplus$
ULUND	$\surd$	$\star\surd\oplus$				
UHELS	$\star\surd\bullet\oplus$	$\star\surd\bullet\oplus$		$\star\bullet\oplus$		
DESY Zeuthen			$\star\surd\oplus$			
UNIBE	$\star\surd\bullet\oplus$	$\star$			$\star\bullet$	
Vienna				$\star$		
Warsaw	$\star\bullet\oplus$	$\star\oplus$	$\star\surd\bullet\oplus$	$\star\oplus$	$\star\bullet\oplus$	$\oplus$

Research Effort of the participants

This network consists of 1 Coordinator and 11 participants, 10 of which from Member States 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 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. The main disagreement concerns the Bern

Table 4: EURIDICE Research Effort after 3 years of operation: Columns (c) and (d) include also the young researchers financed by the Contract

Professional research effort on the network project							
$N.^o$	Team	Young Researchers to be financed by the contract (person-months) (a) as in the contract, (b) as of 31/08/05		Total Researchers financed from all sources (person-months)/year (c) as in the contract, (d) as of 31/08/05		Researchers contributing to the project (number of individuals) (e) as in the contract, (f) as of 31/08/05	
		(a)	(b)	(c)	(d)	(e)	(f)
1.	INFN	48	46	155	183	30	29
2.	UVEG	30	11	200	180	19	19
3.	UAB	30	32	222	240	26	28
4.	CNRS DR12	24	23	80	61	12	9
5.	CNRS-IN2P3	24	12	66	66	12	12
6.	DUR	48	25	60	63	10	10
7.	ULUND	13	23	53	47	6	6
8.	UHELS	13	13	58	41	8	7
9.	DESY Zeuthen	24	13	122	92	13	19
10.	UNIBE	24	23	226	132	13	13
11.	Vienna	24	24	60	63	9	8
12.	Warsaw	0		67	50	11	8
Totals		302	245	1369	1218	169	168

node, with 226 pm/year vs. actual 132 pm/year in colums (c) and (d). Notice that the involvement by the Bern node as stated in the contract contained a factual mistake, since it is impossible to have 226 months/year with 13 researchers. The actual numbers are as stated in the Table.

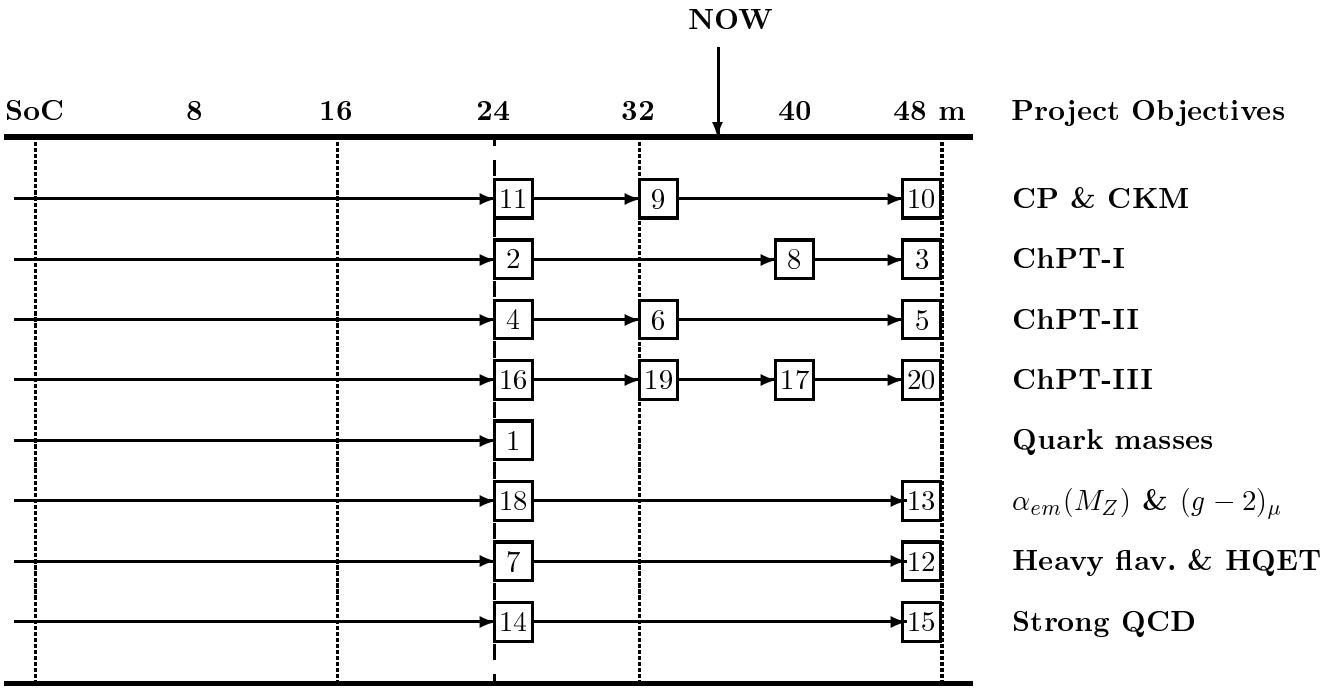
Schedules and Milestones

The Euridice Collaboration project is a joint effort between experimentalists and theorists, aimed to extract informations in the low energy regime explored by the accelerator DAΦNE. As such, some of our milestones are necessarily connected to the progress of the experimental program and may not be completely in line with the original milestones. Such is the case for one particular item, the last one in the milestone table, since the data analysis of the FINUDA experiment is not yet available for theoretical work.

Concerning the other milestones, the general schedule of our work appears well in line with the predictions. To illustrate this, we reproduce the milestone table in our contract. At the right of this table, the objectives of the project are reproduced, while the numbers

in the table refer to the specific tasks related to each objective. Status of accomplishment of the milestones is discussed in conjunction with the table in the next page.

EURIDICE Schedule and Milestones



Legend: SoC=Start of Contract, m=months

Here we list the tasks using different markings to indicate whether a given milestone has been reached or not. As a final comment, concerning the milestone table, we point out that a theoretical project in fundamental physics is really never completed. There are always new features that appear when a given part of the puzzle has been solved. This is why we have refrained from indicating as *completed* many tasks, where work in continuing, although the initial endeavour had been fully undertaken

Tasks:

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

$\star$ completed,

($\star$) near completion,

($\bullet$) work in progress,

$\odot$ initial plan completed, new features under study

2.4 B.4 Organization and Management

2.4.1 B.4.1 Coordination and communication strategy

- *Network organization and management :* The network is 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 operation 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. During the third year of operation, two meetings of the Executive Committee were held :

  1. November 19-20th, 2004 in Frascati to plan for the Midterm and next Collaboration meeting
  2. February 9th, 2005, during the Collaboration Meeting, held in Frascati. During this meeting, preparation of the Midterm Review meeting was finalized, remaining training measures and hiring were discussed and future meetings of the Collaboration were planned.

- *Publications and dissemination of information :* The network results have been published in journals, and/or electronic bulletin boards, and/or presented at Conferences. The publication record of the network can be found from the network webpage, where the publications from each node have a dedicated space. In this space, accessing SPIRES, the link http://www.lnf.infn.it/theory/rtn/papers.htm lists in real time the publications by each member of each node of the network.

- *Presentation at International Conferences :* During the reporting period, network members have participated with presentations and invited talks to many International Conferences, Worshops and Schools. Various members were convenors of dedicated session. In the following, for brevity, we list only the main International Conferences where members of the network gave plenary or invited talks :

  ⋆ The Photon: Its First Hundred Years and the Future in Warsaw and Kazimierz, Poland (30.08-8.09.2005)

  ⋆ 10th International Symposium on Meson-Nucleon Physics and the Structure of the Nucleon, Beijing, China, August 29 - September 4, 2004

  ⋆ European Physical Society High energy Physics Conference in Lisbon (July 2005)

  ⋆ Hadron Physics at COSY conference, Bad Honnef, July 25-29, 2005

  ⋆International Conference on QCD and Hadronic Physics, Beijing, China, 16-20 Jun 2005

⋆ Kaon 2005 International Workshop, Evanston, Illinois (June 2005)

⋆ CKM Workshop in San Diego, USA (March 2005)

⋆ Linear Collider World Study 2005 in Stanford, USA (March 2005)

⋆ 10th International Conference on Structure of Baryons (Baryons 2004) Palaiseau, France, 25-29 Oct 2004

⋆6th Conference on Quark Confinement and the Hadron Spectrum, Villasimius, Sardinia, Italy, 21-25 Sep 2004.

2.4.2 B.4.2 Network meetings

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

⋆ General 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. The list of such meetings follows :

- Meeting of the **Spectroscopy** Group of Euridice, Barcelona, September 16th-18th, 2004.

  Around 50 people attended the meeting from which 20 are members of the Euridice collaboration.

  The meeting consisted in 22 seminars followed by discussions.

- **Midterm Review** and Third **Collaboration Meeting**, February 2005 Frascati, Italy

  Organized by G. Pancheri , attended by 66 participants from the network.

- **HadAtom05**, Workshop on Hadronic Atoms, Bern, February 15-16, 2005. Proceedings:

  L. Afanasyev, G. Colangelo and J. Schacher, *HadAtom05, workshop on hadronic atoms* [hep-ph/0508193].

- LNF Spring **School** Bruno Touschek, Frascati May 16-20th 2005.

  Organized by G. Pancheri, attended by approximately 40 students, including young researchers of the network already hired or to be soon hired, and PhD students from Italian and European Universities from the network.

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 third year of operation, continuing and expanding the collaboration among nodes.

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. All nodes have advertised the available positions.

2.5.2 B.5.2 Progress in recruitment of young reseachers

The training plan is proceeding well. In the accompanying Table 5, we show the original training plan together with the hiring at the end of the third year and the presently committed positions, where pm indicates the length of the contract in person-months.

We notice a few changes wrt the contract or previously expected hiring periods:

1. The INFN node has increased its deliverable from 48 months to 51 months of training, through shift of 1 month of training funds from Orsay node, CNRS/IN2P3 to INFN/LNF. With these funds, the INFN/LNF node has extended the training period of the young researcher Stephanie Trine by three months, until the end of December 2005, when the young researcher will move to a post-doc position in Germany.

2. The Valencia node will be able to use its training funds to deliver 40.5 months of training, ten and a half months more than in the contract.

3. The Barcelona node has delivered 32 months of training, 2 more than the contract deliverable.

4. Following the shift described in (1.), the Orsay node CNRS/IN2P3 is committed to 23 rather than 24 months of training.

5. The post-doc appointed by the DESY Zeuthen node, Dr. Michal Czakon, left earlier having obtained a permanent position. The remaining training months at this node were assigned to the Karlsruhe subnode where A. Grzelinska was hired for the period October 1st 2005 - August 30th 2006.

6. The Lund node has been able to finance the young researcher Timo Lähde for a period of 24 months rather than the originally funded 13, through obtaing for the young researcher a tax free status from the Swedish government.

7. The Vienna node was able to use its funds to increase its training from 24 months to 26 months.

Table 5: Training

Participant	Contract deliverable to YR to be financed by the contract (person-months)			YR financed by the contract so far (person-months)			Committed to start or continue after 01/09/2005 (person-months)
	(a)	(b)	(a+b)	(c)	(d)	(c+d)	
1.INFN-LNF	24	24	48	R. Unterdorfer 9 S. Tsatis 3	C. Smith 23 S. Trine 11	46	S. Trine 4 C. Smith 1
2.UVEG		30	30		J. Hirn 11	11	J. Hirn 12 F. Jugeau 12 R. Bonciani 5,5
3.UAB		30	30		B. Hiesmayr 6 I. Scimemi 6 M. Verbeni 20	32	
4.CNRS-DR12		24	24		S. Necco 23	23	S. Necco 1
5.CNRS/IN2P3		24	24		J. J. Sanz-Cillero 12	12	J. J. Sanz-Cillero 11
6.DUR	24	24	48	J. Hirn 12 K. Benhaddou 2 M. Pappagallo 1	L. Edera 10	25	L. Edera 3 M. Pappagallo 10
7.ULUND		13	13		T. Lähde 23	23	T. Lähde 1
8.UHELS		13	13		B. Julia-Diaz 13	13	
9.DESY Zeuthen		24	24		M. Czakon 13	13	A. Grzelińska 11
10.UNIBE		24	24		B.Kubis 23	23	
11.UWIEN.IT		24	24		R. Kaiser 23 J. Schweizer 1	24	R. Kaiser 1 J. Schweizer 1
TOTAL	48	254	302	27	218	245	73.5

Comment on the state of training

We notice that 81% of the training has already been delivered and that the total training committed so far amounts to 318.4 person-months, larger than the contract deliverable financed by the contract (302 person-months in total). We expect further training months to be delivered by the Durham node, thus going well above the promised training.

To fully see the present state of training, we list the situation in each node, showing both past, present and committed months training. For each young researcher we indicate

- Name
- Type of training
- Date of birth
- Nationality
- Start of contract-end of contract
- Duration of Contract

1. INFN-LNF : 48 months in contract-51 months committed

   Rene Unterdorfer

   Pre-doc (PhD thesis with G. Ecker, scientist in charge of the Vienna node)

   Birth date: 19-02-1976

   Austrian

   September 1st 2003 - May 31st 2004

   9 months

   ****

   Christopher Smith

   Post-doc

   Birth date: 08-04-1974

   Belgian and French

   October 1st 2003 - September 30th 2005

   24 months

   ****

   Stratos Tstatis

   Pre-doc (PhD thesis with Y.N. Srivastava from Perugia University, part of INFN node)

   Birth date: 02-03-1978

Greek
April 30th 2004 - July 31st 2004
3 months

****

Stephanie Trine
Post-doc
Birth date: 29-11-1976
Belgian
October 1st 2004 - December 31st 2005
15 months

2. Universidad de Valencia : 30 months in contract- 40,5 months committed
   Johannes Hirn
   Post-doc
   Birth date: 03-10-1977
   French
   October 1st 2004 - August 31st 2006
   23 months (+1 outside Euridice)
   ****

   Frederic Jugeau
   Post-doc
   Birth date: 28-05-1975
   French
   September 1st 2005 - August 31st 2006
   12 months
   ****

   Roberto Bonciani
   Post-doc
   Birth date : 19-02-1970
   Italian
   September 15th 2005 - February 28th 2006
   5.5 months (+ 18 months outside Euridice)
3. UAB Universitat Autònoma de Barcelona : 30 months in contract-32 months delivered
   Name: Beatrix C. Hiesmayr
   Post-doc

Birth date: 27-01-1975

Austrian

February 1st 2003 - July 31st 2003

6 months

****

Ignazio Scimemi

Post-doc

Birth date: 09-09-1969

Italian

October 1st 2003 - March 31st 2004

6 months

****

Michela Verbeni

Post-doc

Birth date: 16-06-1970

Italian

November 1st 2003 - June 30th 2005

20 months

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

   Sylvia Necco

   Post-doc

   Birth date: 26-05-1974

   Italian

   October 1st 2003 - September 30th 2005

   24 months

5. CNRS-IN2P3 : 24 months in contract-23 month committed

   Juan Jose Sanz-Cillero

   Post-doc

   Birth date: 16-10-1976

   Spanish

   October 1st 2004 - August 31st 2006

   23 months

6. U. of Durham : 48 months in contract-38 months committed

   Johannes Hirn

   PhD Student

Birth date: 03-10-1977

French

October 1st 2003 - September 30th 2004

12 months

****

Kamel Benhaddou

PhD Student

Birth date: 20-11-1973

French

October 1st 2003 - November 30th 2003

2 months

****

Laura Edera

Post-doc

Birth date: 02-02-1975

Italian

November 1st 2004 - December 1st 2005

13 months

****

Marco Pappagallo

PhD student

28 years old

Italian

June 1st 2005 - June 30th 2005

1 month

****

Marco Pappagallo

Post-doc

28 years old

Italian

November 1st 2005 - August 31st 2006

10 months (+1 outside Euridice)

7. U. of Lund : 13 months in contract-24 month committed

   Timo Lähde

   Post-doc

Birth date: 30-07-1977

Finnish

October 1st 2003 - September 30th 2005

24 months

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

   Bruno Julia-Diaz

   Post-doc

   Birth date: 13-09-1975

   Spanish

   June 1st 2003 - June 30th 2004

   13 months (16,5 months)

   Note : For the duration, the number (13 months) is the one from contract. The Helsinki node has covered additional 3,5 months from local sources

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

   Michal Czakon

   Post-doc

   Birth date: 11-04-1974

   Polish

   October 1st 2003 - October 30th 2004

   13 months

   ****

   A. A. Grzelińska

   Post-doc

   Birth date: 26-07-1975

   Polish

   October 1st 2005 - August 30th 2006 at University of Karlsruhe

   11 months

10. U. of Bern : 24 months in contract-23 months delivered

    Bastian Kubis

    Post-doc

    Birth date: 06-02-1974

    German

    November 1st 2002 - September 30th 2004

    23 months

11. U. of Vienna : 24 months in contract-26 months committed

    Roland Kaiser

    Postdoc

    Birth date: 17-02-1972

    Swiss

    October 1st 2003 - September 30th 2005

    24 months

    ****

    Julia Schweizer

    Postdoc

    Birth date: 15-05-1975

    Swiss

    August 1st 2005 - September 30th 2005

    2 months

2.5.3 B.5.3 Integration into the research program

All the young researchers so far have been fully integrated in the research programme, most of them have published their results in refereed journals or in the form of electronic preprints and the relative papers have been submitted for publication in the international journals. All the young reearchers have had the opportunity to participate to the Collaboration meeting, present their work and interact with the senior scientists.

2.5.4 B.5.4 Training measures

The measures undertaken in the training program concerned both individual and common training. Common training was performed through attendance to the Spring School, participation and attendance to the Collaboration Meeting and participation to the topical Workshops dedicated to the research topics of interest for the young researcher. Individual training consisted in collaboration exchanges and secondments to other nodes to work on common projects. All these activities are listed in the individual nodes reports.

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.

Among the 19 young researchers trained during the third year of operation, 6 of them were women, representing a proportion of 32%, higher than what is usually reported for the presence of women in the field of theoretical physics (according to INFN statistics of the year 2000, in Italy only 11% of the total number of theoretical particle physicists with permanent positions were women).

Special attention has been devoted in all the nodes to training and retaining of young women physicists, by extending their contract whenever possible so as to allow flexibility for special personal needs. We consider that the presence of women in leading positions in this network has increased the awareness of all the node scientists to the special plight of women physicists and that this reflects the good record in training of young women researchers.

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, an important component of the research effort of the the Barcelona and Vienna node, involves a certain degree of interdisciplinarity.

2.6 B.6 Difficulties and changes w.r.t the contract

No difficulties have been reported. A change in the distribution of funds has been approved by the network (and communicated tho the EU officer), whereupon one month of training funds has been transferred from the Orsay (CNRS-IN2P3) node to Frascati (INFN/LNF), to complete training of the young researcher Stephanie Trine. The extension of the contract will be reported in the next period, since this change will take place from october 2005 onwards.