Second 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

Second Periodic Progress Report 01/09/2003 - 31/08/2004

Contents

1 Part 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**
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 second period will be discussed. During the second year of operation, remarkable progress was done by the experimental group KLOE, whose members in the network work in close collaboration with the theorists. A separate subsection has thus been devoted to describe the main scientific highlights obtained by the experimental group.

1.1 A1. Scientific Highlights

In this section we summarize the main scientific results of the network during the second year of operation. The joint publications are included following a brief, necessarily incomplete, description of the main scientific content. 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 are ordered according to participant number.

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

CP-, T- and CPT-violating parameters

To help clarify the origin of CP-violation:

- Isospin breaking corrections to the direct-CP-violating observable ε'/ε were calculated by the Valencia and Vienna nodes, including both strong isospin violation and electromagnetic corrections to next-to-leading order in the low-energy expansion. Destructive interference was found between three different sources of isospin violation in ε'/ε.

Rare Decays

CP violation and rare decays:

- A new study of the rare decay $K_L \to \pi^0\mu^+\mu^-$ within CHPT, performed by a joint LNF-Vienna collaboration, has demonstrated that also this mode can be used (in the future) to perform precision tests of short-distance dynamics in $\Delta S = 1$ transitions.

- The Marseille group has performed an updated discussion of $K \to \pi \bar{l} l$ decays in a combined framework of chiral perturbation theory and Large–N_c QCD, which assumes the dominance of a minimal narrow resonance structure in the invariant mass dependence of the $\bar{l}l$ pair. The proposed picture reproduces very well, both the experimental $K^+ \to \pi^+ e^+ e^-$ decay rate and the invariant e^+e^- mass spectrum. The predicted $\mathrm{Br}(K_S \to \pi^0 e^+ e^-)$ is, within errors, consistent with the recently reported result from the NA48 collaboration. Predictions for the $K \to \pi\ \mu^+\mu^-$ modes are also obtained. We find that the resulting interference between the *direct* and *indirect* CP–violation amplitudes in $K_L \to \pi^0 e^+ e^-$ is constructive.

- The Bern node has investigated the rare process $B \to X_d l^+ l^-$ at next-to-next-to-leading logarithmic order for the branching ratio, the CP-asymmetry and the forward-backward asymmetry.

Quantum mechanics and the neutral meson system: QM

- The Barcelona-Turin-Vienna collaboration has extended the analysis of Bell inequalities and other QM effects using the neutral kaon system. Some of the proposals could be tested at DAΦNE.

- The Vienna group has discussed the feasibility of an experiment determining the decoherence parameter with experts from the Institute for High Energy Physics of the Austrian Academy of Sciences.

- The quantitative formulation of Bohr's complementarity was applied by the Vienna group to physical situations for which analytical expressions are available. This includes a variety of conventional double-slit experiments, but also particle oscillations (neutral kaons, B mesons) and Mott scattering of identical nuclei.

- Together with an experimental group at the Atominstitut in Vienna, the Vienna node has proposed an experiment with neutron interferometry that connects the Berry phase, a geometric phase, with the violation of a Bell inequality.

To improve the theoretical precision for the CKM matrix elements: CKM MATRIX

- The LNF group, in collaboration with external members from Rome universities, has presented a new high-precision study of the $K \to \pi$ form factor, relevant for the extraction of the CKM matrix element V_{us}. The analysis is performed combining Lattice QCD and CHPT techniques.

- The determination of the CKM angle γ through CP asymmetries in three-body B-decays has been investigated for $B^- \to \pi^+\pi^-K^-$ and $B^- \to K^+K^-K^-$, $B^- \to \phi\phi K^-$ with the $\phi\phi$ invariant mass below the charm threshold by the Orsay node.

- A detailed numerical study of K_{e3} decays to $O(p^6, (m_d - m_u)p^2, e^2p^2)$ was performed by the Vienna group, describing the extraction of the CKM matrix element $|V_{us}|$ from the experimental K_{e3} decay parameters. A consistency check of the K^+_{e3} and K^0_{e3} data was proposed that is largely insensitive to the dominating theoretical uncertainties, in particular the contributions of $O(p^6)$.

1.1.2 Chiral Perturbation Theory

ChPT

- The Bern group has finalized the evaluation of the spectra and decay widhts of $\pi^{\pm}K^{\mp}$ and $\pi^{+}\pi^{-}$ atoms.
- ChPT allows one to perform extrapolation to large volumes and small quark masses in lattice calculations through analytic methods. The group Bern-Zeuthen has taken up this issue and analyzed the behaviour of the pion mass and of the pion decay constant (Bern group) in a finite volume.
- The decay $\tau^{-} \to (\pi\pi\pi)^{-}\nu_{\tau}$ was studied within the framework of the Resonance Effective Theory of QCD by the Valencia-Granada collaboration.
- The $\langle VAP \rangle$ Green function was studied by the Valencia and Vienna nodes. A resonance dominated Green function was confronted with the operator product expansion and shown to be compatible with a chiral resonance Lagrangian.
- The vector form factor of the pion at next–to–leading order in the $1/N_C$ expansion was analyzed by the Valencia node.
- The matrix elements of $\Delta I = 3/2$ transitions in $K \to \pi\pi$ were studied within lattice QCD by the Valencia group.
- A ChPT analysis of the role of the charm flavour in the $\Delta I = 1/2$ rule of non-leptonic kaon decays was undertaken by the Valencia group.
- Progress on the nature of scalar mesons has been made by connecting the Linear Sigma Model with modern ChPT by the Barcelona node.
- The Lund and Barcelona nodes have made strong progress by performing the full two-loop calculation in 3 flavour ChPT of $\pi\pi$ and πK scattering and the first two-loop calculation in partially quenched ChPT.
- The local part of isospin breaking in $K \to 3\pi$ decays was calculated by the Lund node.

To determine effective low-energy couplings from first principles:

Effective Coupling constants

- A joint project of the Valencia and Vienna nodes investigates the matching of Green functions between the low-energy behaviour given by chiral perturbation theory and the high-energy structure dictated by QCD. In the spirit of large N_c, the Green functions in the intermediate-energy range are assumed to be given by meson resonance exchange. The matching yields values for some of the chiral low-energy constants of $O(p^6)$.
- Non–perturbative renormalization of coupling constants on the lattice was studied by the Valencia group.

Chiral Couplings from the Lattice

- Members of the Marseille, Zeuthen and Valencia nodes have pursued the analytical computation of non-singlet vector and axial vector two-point functions in sectors of fixed topology at NLO in the ϵ-expansion of chiral perturbation theory. The resulting expressions can be used to determine the couplings of the leading order chiral lagrangian from lattice simulations in the finite-size scaling regime of QCD.

- The Orsay node has 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. In the range $E < 1\,\mathrm{GeV}$, precise numerical solutions were obtained which make use as input 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. The main result was a tight constrain on the two S-wave scattering lengths.

ROY-STEINER EQUATIONS

To investigate the order parameters of QCD:

ORDER PARAMETERS

- The Orsay node has 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.

Baryon ChPT and Hypernuclei:

BARYON CHPT

- A systematic study of the electromagnetic and axial vector current matrix elements of the baryons and the baryon resonances was carried out in instant, point and front form kinematics with the constituent quark model by the Helsinki group.

1.1.3 Quark masses

QUARK MASSES

- The formulas needed for the extrapolation of partially quenched lattice data to the physical case have been extended to two loop order for the case of 3 flavours and separately degenerate valence and degenerate sea quark masses by the Lund node.

- The Orsay node proposed a framework to deal with potentially large vacuum fluctuations of $s\bar{s}$ pairs in three-flavour ChPT. The latest data on $\pi\pi$ scattering were shown to yield the lower bound for the quark mass ratio $r = m_s/m > 14$ with 95

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

$(g-2)_\mu$ AND $\alpha_{em}(M_Z)$

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

- The INFN-Bologna group, in collaboration with the Karlsruhe and Warsaw nodes, has continued an intense activity about analytic and/or numeric evaluations of multi-loop amplitudes: i) two loop (and more) analytic calculations for Bhabha scattering and others QED quantities; ii) two loop analytic corrections to QCD quantities; iii) two loop precise numerical evaluations (even on thresholds) of a selfmass with arbitrary masses from differential equations.

The electroweak contribution:

- New non renormalization theorems involving the transverse, i.e. non anomalous, part of the QCD three point function $\langle VVA \rangle$, which describes two loop electroweak corrections to the muon $g-2$, were proven by a joint Marseille-Barcelona collaboration.

Hadronic Effects in electroweak precision observables

- The Bern group in collaboration with DESY Zeuthen has continued its work on evaluating the hadronic vacuum polarization contribution below 1 GeV to a_μ within a framework that relies on analyticity, unitarity and chiral symmetry, as well as on data.

- The higher order contributions from hadronic vacuum polarization to the muon $g-2$ have been reanalyzed by the Marseille group, who found a simple way of explaining the negative sign of this contribution, as well as a good estimate from simple evaluations of asymptotic behaviours. The scalar exchange contribution to the hadronic light-by-light was reexamined within a large-N_C inspired approach and its sensitivity to various properties of the scalars (mass, width, mixing angle) were studied.

- Katowice-Karlsruhe-Valencia collaboration resulted in a number of new developments helping in hadronic cross section measurements via radiative return method at meson factories, namely calculating next-to-leading order radiative corrections to final state emission for pion pair production, with implementation in PHOKHARA Monte Carlo event generator, proposing new physical measurements and tests of existing models of hadronic interactions, possible due to radiative return method, and calculating ext-to-leading order radiative corrections to final state photon emission in the process $e^+e^- \to \mu^+\mu^-\gamma(\gamma)$.

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

HEAVY FLAVOUR DECAYS

- A systematic study of Bjorken-like sum rules in the heavy quark limit of QCD has been performed by the Orsay node. 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.

- 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 $B \to \gamma l^+ l^-$ by the Orsay node. Resummation of large Sudakov logarithms present at all orders of perturbation theory has been discussed in the framework of the "Soft Collinear Effective Theory". Factorisation has been proved at one-loop order for the spectator interactions involving the light quark inside the B-meson in the radiative decays $B \to V\gamma$ (with V a vector meson).

- The extraction of charge and matter radial distributions for S-wave heavy-light mesons using lattice QCD was done by the Helsinki node

- The Oslo node studied colour suppressed B decays with vector mesons in the final state

1.1.6 Strong Interaction limit of QCD

α_s

α_s in the infrared region :

- The LNF and Perugia groups, in collaboration with the Granada team from Barcelona node, have performed a new study of the proton-proton and antiproton cross-section using the soft-gluon resummation and singular α_S formalism developed in earlier work.
- The Warsaw and Granada teams continued study of the partonic structure of photon, especially its heavy quark content, constructing a LO and NLO order parton parametrization for the photon, a question of primary importance for testing hadronic interaction of the photon.

To firmly establish the new glueball spectroscopy and clarify the effect of strong interactions in heavy flavour decays :

SPECTROSCOPY

- The Orsay group has investigated 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, a covariant three-dimensional bound state equation for the quarkonium system was obtained.

Meson and baryon Spectroscopy beyond the naive Quark Model :

- Valencia studied radiative decays of the ϕ meson and their comparison with KLOE (DAPHNE) data. Evaluation of the decay rates of $J/\psi \to PP\,(\phi,\omega)$ and $J/\psi \to \pi\pi\, p\overline{p}$, where P is short for pseudoscalar meson was done.
- Study of the dynamical generation of baryonic resonances and consequent description of many known and new resonances was done by the Valencia node. Several of the later ones are under investigation in some Laboratories. In particular a resonance of positive strangeness coming from $\Delta\, K$ interaction in $I = 1$ is predicted.
- Analysis of pentaquark states to determine spin and parity of the Θ^+, its possible origin as a $K\pi N$ bound state and the existence of hypernuclei of Θ^+ was done by the Valencia node.
- A major interest of the UK node has been in the new hadronic states, both mesons and baryons, that have been discovered in a series of experiments at BaBar, Belle, Fermilab and JLAB. The focus has been on the interpretation of these states and their relation to QCD dynamics.
- The review "Mesons beyond the naive quark model" for Physics Reports, has been published by the Helsinki node. This includes theoretical predictions and experimental observations on possible four-quark states, deuteronlike mesonic states, the light scalars, glueballs and hybrid mesons.

New baryons

- The existence of bound deuteron-like states of the recently discovered double-charm hyperons and nucleons were studied by the Helsinki node extrapolating a set of realistic nucleon-nucleon interactions to the heavy flavor hyperons. The different interaction models led to widely different calculated binding energies, yet allowing the overall conclusion that deuteron-like bound states of double-charm hyperons are likely.
- The Warsaw node worked on new experimental proposals among others on K-D atoms, AIC project for new GSI Darmstadt. This is related to a fresh KEK discovery of a strongly bound K-NNN system. It is apparently related to sub-threshold K-N anplitude and may be tested in K-D, K-He atoms.

1.1.7 Experimental progress of KLOE.

In the last 12 months, the KLOE collaboration has performed several new measurements of K decays, radiative Φ decays and low-energy hadronic cross sections analyzing the 450 pb^{-1}

collected during 2001-2002 running. A new data taking has started on May 2004 and the experiment is expected to collect 2 fb^{-1} in the coming year. The most significant analysis results can be summarized as follows:

1. finalized measurement of the pion form factor using the radiative return method, and the related evaluation of the hadronic contribution to $(g-2)_\mu$ with a systematic error of 0.9%(exp) $\otimes$ 0.9 %(theory).

2. preliminary measurement of branching ratios, BR, for all main K_L decay modes via K_L tagging. The BR measurement for $K_L \to \pi^\pm e^\mp \nu$ and $K_L \to \pi^\pm \mu^\mp \nu$, together with a new determination of the K_L lifetime, are relevant for the extraction of the CKM element $|V_{us}|$;

3. updated results on branching ratios and charge asymmetry of $K_S \to \pi^\pm e^\mp \nu$ decays (relevant both for V_{us} and for CPT tests);

4. upper bound on the rare $K_S \to 3\pi^0$ decay (relevant for CP and CPT tests);

5. for radiative Φ decays there are updated results on $\Phi \to \eta'\gamma$, $f^0(980)\gamma$, $a^0(980)\gamma$ and brand new measurements such as: study of the dalitz-plot distributions for $\eta \to 3\pi$ decays, search for the rare decay $\eta \to \pi^0\gamma\gamma$ and upper-limits for the $\eta \to \pi^+\pi^-$ process. A first observation of the $f^0(980) \to \pi^+\pi^-$ decay has also been obtained by studying the $M(\pi^+\pi^-)$ spectrum in the $\pi^+\pi^-\gamma$ final state with large angle photons.

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**. 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

1. M. Battaglia *et al.*, *The CKM matrix and the unitarity triangle*, hep-ph/0304132. **(multiple institutes)**

2. A. Bramon, G. Garbarino and B. C. Hiesmayr, *Active and passive quantum erasers for neutral kaons*, Phys. Rev. **A69** (2004) 062111 [quant-ph/0402212]. **Joint INFN–Barcelona–Vienna.**

3. A. Bramon, G. Garbarino and B.C. Hiesmayr, *Quantum marking and quantum erasure for neutral kaons*, Phys. Rev. Lett. **92** (2004) 020405 (also selected for Virtual Journal of Quantum Information, Feb. 2004, vol. 4, issue 2). **Joint INFN–Barcelona–Vienna.**

4. A. Bramon, G. Garbarino and B.C. Hiesmayr, *Quantitative duality and neutral kaon interferometry in CPLEAR experiments*, Eur. Phys. J. **C32** (2004) 377. **Joint INFN–Barcelona–Vienna.**

5. A. Bramon, G. Garbarino and B.C. Hiesmayr, *Quantitative complementarity in two-path interferometry*, Phys. Rev. **A69** (2004) 022112. **Joint INFN–Barcelona–Vienna.**

6. G. Garbarino, A. Parreno, A. Ramos, *Towards a solution of the* Γ_n/Γ_p *puzzle in the nonmesonic weak decay of* Λ*-hypernuclei*, Eur. Phys. J. **C32** (2004) 377. **Joint INFN–Barcelona.**

7. P. Colangelo, F. De Fazio and T. N. Pham, *The riddle of polarization in* $B \to V\,V$ *transitions*, Phys. Lett. **B597** (2004) 291 [hep-ph/0406162]. **Joint INFN–Orsay.**

8. P. Colangelo, F. de Fazio and T. N. Pham, *Nonfactorizable contributions in B decays to charmonium: The case of* $B \to K^- h_c$, Phys. Rev. **D69** (2004) 054023 [hep-ph/0310084]. **Joint INFN–Orsay.**

9. R. Bonciani, P. Mastrolia and E. Remiddi, *Master integrals for the 2-loop QCD virtual corrections to the forward-backward asymmetry*, Nucl. Phys. **B690** (2004) 138 [hep-ph/0311145]. **Joint INFN–DESY/Karlsruhe.**

10. R. Bonciani, A. Ferroglia, P. Mastrolia, E. Remiddi and J. J. van der Bij, *Planar box diagram for the (N(F) = 1) 2-loop QED virtual corrections to Bhabha scattering*, Nucl. Phys. **B681** (2004) 261 [hep-ph/0310333]. **Joint INFN–DESY/Karlsruhe.**

11. S. Laporta, P. Mastrolia and E. Remiddi, *The analytic value of a 4-loop sunrise graph in a particular kinematical configuration*, Nucl. Phys. **B688** (2004) 165 [hep-ph/0311255]. **Joint INFN–DESY/Karlsruhe.**

12. A. Aloisio *et al.* [KLOE Collaboration], *Upper limit on the $\eta \to \gamma\gamma\gamma$ branching ratio with the KLOE detector*, Phys. Lett. **B591** (2004) 49 [hep-ex/0402011]. **Joint INFN–DESY/Karlsruhe.**

13. A. Aloisio *et al.* [KLOE Collaboration], *Data acquisition and monitoring for the KLOE detector*, Nucl. Instr. Meth. Phys. **A516** (2004) 288. **Joint INFN–DESY/Karlsruhe.**

14. A. Aloisio *et al.* [KLOE Collaboration], *Measurement of the branching ratio for the decay $K^{\pm} \to \pi^{\pm}\pi^o\pi^o$ with the KLOE detector*, Phys. Lett. **B597** (2004) 139 [hep-ex/0307054]. **Joint INFN–DESY/Karlsruhe.**

15. M. Moulson *et al.* [KLOE Collaboration], *The KLOE computing environment*, IEEE Trans. Nucl. Sci. **51** (2004) 897. **Joint INFN–DESY/Karlsruhe.**

16. A. Ghinculov, T. Hurth, G. Isidori and Y. P. Yao, *The rare decay $B \to X_s l^+ l^-$ to NNLL precision for arbitrary dilepton invariant mass*, Nucl. Phys. **B685** (2004) 351 [hep-ph/0312128]. **Joint INFN–Bern/Zurich.**

17. G. Isidori, C. Smith and R. Unterdorfer, *The rare decay $K_L \to \pi^0\mu^+\mu^-$ within the SM*, Eur. Phys. J. **C36** (2004) 57 [hep-ph/0404127]. **Joint INFN–Vienna.**

18. G. Isidori and R. Unterdorfer, *On the short-distance constraints from $K_{L,S} \to \mu^+\mu^-$*, JHEP **0401** (2004) 009 [hep-ph/0311084]. **Joint INFN–Vienna.**

19. M. Caffo, H. Czyż, A. Grzelińska and E. Remiddi, *Numerical evaluation of the general massive 2-loop 4-denominator self-mass*, Nucl. Phys. **B681** (2004) 230 [hep-ph/0312189]. **Joint INFN–Warsaw.**

20. A. Ramos, E. Oset, C. Bennhold, *Low-lying $J_P = 1/2$-resonances from chiral unitary dynamics*, Nucl. Phys. **A721** (2003) 711. **Joint Valencia–Barcelona.**

21. T. Hyodo, A. Hosaka, E. Oset, A. Ramos and M. J. Vicente Vacas, *Lambda(1405) production in the $\pi^- p \to K^0\pi\Sigma$ reaction*, Phys. Rev. **C68** (2003) 065203 [nucl-th/0307005]. **Joint Valencia–Barcelona.**

22. A. Gómez Nicola, J. Nieves, J.R. Peláez, E. Ruiz Arriola, *Improved unitarized heavy baryon chiral perturbation theory for pion nucleon scattering to fourth order*, Phys. Rev. **D69** (2004) 076007. **Joint Valencia–Granada.**

23. L. Giusti, P. Hernández, M. Laine, P. Weisz, H. Wittig, *Low-energy couplings of QCD from topological zero mode wave functions*, JHEP **0401** (2004) 003 [hep-lat/0312012]. **Joint Valencia–Marseille.**

24. L. Giusti, P. Hernández, M. Laine, P. Weisz, H. Wittig, *Low-energy couplings of QCD from current correlators near the chiral limit*, JHEP **0404** (2004) 013 [hep-lat/0402002]. **Joint Valencia–Marseille.**

25. H. Czyż, J. H. Kühn, E. Nowak and G. Rodrigo, *Nucleon form factors, B-meson factories and the radiative return*, Eur. Phys. J. **C35** (2004) 527 [hep-ph/0403062]. **Joint Valencia-DESY/Karlsruhe–Warsaw/Katowice.**

26. H. Czyż, A. Grzelińska, J. H. Kühn and G. Rodrigo, *The radiative return at Φ and B-factories: FSR at next-to-leading order*, Eur. Phys. J. **C33** (2004) 333 [hep-ph/0308312] **Joint Valencia-DESY/Karlsruhe–Warsaw/Katowice.**

27. V. Cirigliano, H. Neufeld and H. Pichl, *K_{e3} decays and CKM unitarity*, Eur. Phys. J. **C35** (2004) 53 [hep-ph/0401173]. **Joint Valencia–Vienna.**

28. V. Cirigliano, G. Ecker, H. Neufeld, A. Pich, *Isospin violation in ϵ'*, Phys. Rev. Lett. **91** (2003) 162001 [hep-ph/0307030]. **Joint Valencia–Vienna.**

29. V. Cirigliano, G. Ecker, H. Neufeld, A. Pich, *Isospin breaking in $K \to \pi\pi$ decays*, Eur. Phys. J. **C33** (2004) 369 [hep-ph/0310351]. **Joint Valencia–Vienna.**.

30. V. Cirigliano, G. Ecker, M. Eidemüller, A. Pich, J. Portolés, *$\langle VAP \rangle$ Green function in the Resonance Region*, Phys. Lett. **B596** (2004) 96 [hep-ph/0404004]. **Joint Valencia–Vienna.**

31. M. Knecht, S. Peris, M. Perrottet and E. de Rafael, *New nonrenormalization theorems for anomalous three point functions*, JHEP **0403** (2004) 035 [hep-ph/0311100]. **Joint Barcelona–Marseille.**

32. J. Bijnens, P. Dhonte and P. Talavera, *πK scattering in three flavor ChPT*, JHEP **0405** (2004) 036 [hep-ph/0404150]. **Joint Barcelona–Lund.**

33. J. Bijnens, P. Dhonte and P. Talavera, *$\pi\pi$ scattering in three flavour ChPT*, JHEP **0401** (2004) 050 [hep-ph/0401039]. **Joint Barcelona–Lund.**

34. E. Gamiz, J. Prades and I. Scimemi, *Charged kaon $K \to 3\pi$ CP violating asymmetries at NLO in ChPT*, JHEP **0310** (2003) 042 [hep-ph/0309172]. **Joint Barcelona/Granada–Bern.**

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

36. S. Dürr and C. Hölbling, *Staggered versus overlap fermions: A study in the Schwinger model with $N(f) = 0, 1, 2$*, Phys. Rev. **D69** (2004) 034503 [hep-lat/0311002]. **Joint Marseille–DESY/Zeuthen.**

37. J. Hirn and J. Stern, *The role of spurions in Higgs-less electroweak effective theories*, Eur. Phys. J. **C34** (2004) 447 [hep-ph/0401032]. **Joint Orsay–Durham.**

38. M. Awramik, M. Czakon, A. Freitas and G. Weiglein, *Precise prediction for the W-boson mass in the standard model*, Phys. Rev. **D69** (2004) 053006 [hep-ph/0311148]. **Joint Durham–DESY/Zeuthen.**

39. A.M. Green and S. Wycech, *η-π mixing close to the η-Helium threshold*, Phys. Rev. **C68** (2004) 061601 [nucl-th/0308057]. **Joint Helsinki–Warsaw.**

40. C. Amsler and N. A. Törnqvist, *Mesons beyond the naive quark model*, Phys. Rept. **389** (2004) 61. **Joint Helsinki–Bern.**

41. G. Colangelo and S. Dürr, *The pion mass in finite volume*, Eur. Phys. J. **C33** (2004) 543 [hep-lat/0311023] **Joint DESY/Zeuthen–Bern.**

1.2.2 Conference Proceedings

1. A. Bramon, G. Garbarino and B. C. Hiesmayr, *Passive quantum erasure for neutral kaons*, Contributed to Festschrift in Honor of Prof. Jose Adolfo de Azcarraga for his 60th Birthday, Salamanca, Spain, 9-11 Jun 2003 [quant-ph/0404086]. **Joint INFN–Barcelona–Vienna.**

2. A. Bramon, G. Garbarino and B. C. Hiesmayr, *Quantitative duality and quantum erasure for neutral kaons*, eConf **C0309101**, THWP005 (2003). Invited talk at Workshop on e+ e- in the 1-GeV to 2-GeV Range: Physics and Accelerator Prospects - ICFA Mini-workshp - Working Group on High Luminosity e+ e- Colliders, Alghero, Sardinia, Italy, 10-13 Sep 2003, [hep-ph/0311232]. **Joint INFN–Barcelona–Vienna.**

3. W. M. Alberico, G. Garbarino, A. Parreno and A. Ramos, *Towards a solution of the Γ_n/Γ_p puzzle in the weak decay of Λ hypernuclei*, Short talk given at DAΦNE 2004: Workshop on Physics at Meson Factories, Rome, Frascati, Italy, 7-11 Jun 2004 [nucl-th/0407046]. **Joint INFN–Barcelona.**

4. G. Garbarino, A. Parreno and A. Ramos, *Non-mesonic weak decay of Λ hypernuclei: A new determination of the Γ_n/Γ_p ratio*, Invited talk at 8th International Conference on Hypernuclear and Strange Particle Physics (HYP 2003), Newport News, Virginia, 14-18 Oct 2003 [nucl-th/0312040]. **Joint INFN–Barcelona.**

5. J. Gasser, B. Kubis, N. Paver, M. Verbeni, *Comments on Radiative $K_{\ell 3}$ Decays*, Invited talk at MESON 2004: 8th International Workshop on Meson Production, Properties and Interactions, Cracow, Poland, 4-8 Jun 2004. Submitted to Int.J.Mod.Phys.A. **Joint INFN–Barcelona/Granada-Bern.**

6. R. M. Godbole, A. Grau, G. Pancheri and Y. N. Srivastava, *Photon total cross-sections*, Talk given at Photon 2003: International Conference on the Structure and Interactions of the Photon and 15th International Workshop on Photon-Photon Collisions, Frascati, Italy, 7-11 Apr 2003, Nucl. Phys. Proc. Suppl. **126** (2004) 94 [hep-ph/0311211]. **Joint INFN–Barcelona/Granada.**

7. A. Grau, S. Pacetti, G. Pancheri and Y. N. Srivastava, *Bloch-Nordsieck resummation for QCD processes*, Prepared for Photon 2003: International Conference on the Structure and Interactions of the Photon and 15th International Workshop on Photon-Photon Collisions, Frascati, Italy, 7-11 Apr 2003. Nucl. Phys. Proc. Suppl. **126** (2004) 84. **Joint INFN–Barcelona/Granada.**

8. S. E. Müller for the KLOE Collaboration, *Measurement of the e^+e^- hadronic cross section at DAΦNE via radiative return*, International Conference on the Structure and Interactions of the Photon including the $15^{\rm th}$ International Workshop on Photon-Photon Collisions, Frascati, April 7 - 11, 2003, Nucl. Phys. Proc. Suppl. **126** (2004) 335 **Joint INFN–DESY/Karlsruhe.**

9. B. Valeriani-Kaminski for the KLOE Collaboration, *The hadronic cross section measurement at KLOE*, Workshop on Hadronic Cross Section at Low Energy SIGHAD03, Pisa, Oct. 8-10, 2003, Nucl. Phys. Proc. Suppl. **B131** (2004) 75. **Joint INFN–DESY/Karlsruhe.**

10. A. Denig for the KLOE Collaboration, *Measurement of the hadronic cross-section at DAΦNE with the KLOE detector*, 10^{th} International Conference on Hadron Spectroscopy, Hadron 03, Aschaffenburg, Germany, 31 Aug - 6 Sep 2003. to appear in the proceedings, [hep-ex/0311012]. **Joint INFN–DESY/Karlsruhe.**

11. A. G. Denig *et al.* [KLOE Collaboration], *KLOE perspectives for R-measurements at DAΦNE2*, Invited talk at Workshop on e+ e- in the 1-GeV to 2-GeV Range: Physics and Accelerator Prospects - ICFA Mini-workshp - Working Group on HIgh Luminosity e+ e- Colliders, Alghero, Sardinia, Italy, 10-13 Sep 2003, eConf **C0309101**, FRWP009 (2003) [hep-ex/0403005]. **Joint INFN–DESY/Karlsruhe.**

12. A. Aloisio *et al.* [KLOE Collaboration], *KLOE results on rare K0 decays*, Invited talk at Workshop on e+ e- in the 1-GeV to 2-GeV Range: Physics and Accelerator Prospects - ICFA Mini-workshp - Working Group on High Luminosity e+ e- Colliders, Alghero, Sardinia, Italy, 10-13 Sep 2003, eConf **C0309101**, THWP004 (2003) [hep-ex/0402030]. **Joint INFN–DESY/Karlsruhe.**

13. A. Aloisio *et al.* [KLOE Collaboration], *Measurement of* $\sigma\left(e^+e^- \to \pi^+\pi^-\right)$ *at DAΦNE with the radiative return*, Invited talk at Workshop on e+ e- in the 1-GeV to 2-GeV Range: Physics and Accelerator Prospects - ICFA Mini-workshp - Working Group on HIgh Luminosity e+ e- Colliders, Alghero, Sardinia, Italy, 10-13 Sep 2003, eConf **C0309101**, FRWP008 (2003) [hep-ex/0312056]. **Joint INFN–DESY/Karlsruhe.**

14. A. Di Domenico *et al.* [KLOE Collaboration], *Kaon interferometry at KLOE: Present and future*, Contributed to Workshop on e+ e- in the 1-GeV to 2-GeV Range: Physics and Accelerator Prospects - ICFA Mini-workshp - Working Group on HIgh Luminosity e+ e- Colliders, Alghero, Sardinia, Italy, 10-13 Sep 2003. eConf **C0309101**, THWP007 (2003) [hep-ex/0312032]. **Joint INFN–DESY/Karlsruhe.**

15. S. Di Falco for the KLOE Collaboration], *Latest results from DAΦNE*, Presented at 27th International Conference of Theoretical Physics: Matter to the Deepest: Recent Developments in Physics of Fundamental Interactions (Ustron 03), Ustron, Poland, 15-21 Sep 2003. Acta Phys. Polon. **B34** (2003) 5207 [hep-ex/0311006]. **Joint INFN–DESY/Karlsruhe.**

16. C. Gatti for the KLOE Collaboration], *Scalar mesons and* $\delta_0 - \delta_2$ *at KLOE*, Talk given at QCD @ Work 2003: 2nd International Workshop on Quantum Chromodynamics: Theory and Experiment, Conversano, Italy, 14-18 Jun 2003, eConf **C030614** (2003) 003 [hep-ex/0310031]. **Joint INFN–DESY/Karlsruhe.**

17. C. Di Donato for the KLOE Collaboration, *Measurement of the phi meson radiative decays into scalar and pseudoscalar mesons with the KLOE detector*, Nucl. Phys. Proc. Suppl. **126** (2004) 199. **Joint INFN–DESY/Karlsruhe.**

18. F. Nguyen for the KLOE collaboration, *Measurement of the $\sigma(e^+e^- \to \pi^+\pi^-\gamma)$ cross section below $1GeV$ with the KLOE detector*, DAΦNE 2004, Physics at meson factories, 7-11 June 2004, LNF Frascati (Roma), to be published in the Proceedings. **Joint INFN–DESY/Karlsruhe.**

19. A. Denig for the KLOE collaboration, *Recent results from KLOE at the e^+e^- collider DAΦNE*, 10^{th} Int. Symposium on Meson-Nucleon Physics and the Structure of the Nucleon, Aug 29 - Sep. 4, 2004, MENU 2004, Beijing, to appear in the proceedings. **Joint INFN–DESY/Karlsruhe.**

20. S. E. Müller for the KLOE collaboration, *Measurement of the hadronic cross section $\sigma(e^+e^- \to \pi^+\pi^-\gamma)$ with KLOE*, 10^{th} Int. Symposium on Meson-Nucleon Physics and the Structure of the Nucleon, Aug 29 - Sep 4, 2004, MENU 2004, Beijing, to appear in the proceedings. **Joint INFN–DESY/Karlsruhe.**

21. W. Kluge for the KLOE collaboration, *The reaction $\sigma(e^+e^- \to \pi^+\pi^-)$ and its relation to the anomalous magnetic moment of the muon*, Int. Conf. on Hadron Structure 2004, HS 2004, 30 Aug- 3 Sep, Smolenice (Slovakia), to appear in the proceedings. **Joint INFN–DESY/Karlsruhe.**

22. A. Ghinculov, T. Hurth, G. Isidori and Y. P. Yao, *New NNLL QCD results on the decay $B \to X_s\ell^+\ell^-$*, Invited talk given by T.H. at International Europhysics Conference on High-Energy Physics (HEP 2003), Aachen, Germany, 17-23 Jul 2003, Eur. Phys. J. **C33** (2004) S288 [hep-ph/0310187]. **Joint INFN–Bern/Zurich.**

23. T. Hyodo, A. Hosaka, M. J. Vicente Vacas, E. Oset and A. Ramos, *$\Lambda(1405)$ production in the pi- p $\to$ K0 pi Sigma reaction*, prepared for Workshop on Strangeness Nuclear Physics at J-PARC, Tsukuba, Japan, 29-31 Jul 2003. **Joint Valencia–Barcelona.**

24. D. Jido, J.A. Oller, E. Oset, A. Ramos, U.G. Meissner, *Chiral dynamics of the two $\Lambda(1405)$ states*, Talk given at Workshop on the Physics of Excited Nucleons (NSTAR 2004), Grenoble, France, 24-27 Mar 2004 [nucl-th/0406047]. **Joint Valencia–Barcelona.**

25. A. Ramos, E. Oset, C. Bennhold, D. Jido, J.A. Oller, U.G. Meissner, *Dynamical generation of hyperon resonances*, Invited talk at 8th International Conference on Hypernuclear and Strange Particle Physics (HYP 2003), Newport News, Virginia, 14-18 Oct 2003 [nucl-th/0312013]. **Joint Valencia–Barcelona.**

26. P. H. Damgaard, P. Hernandez, K. Jansen, M. Laine and L. Lellouch, *Vector and axial-vector propagators in the epsilon-regime of QCD*, 21st International Symposium on Lattice Field Theory (LATTICE 2003), Tsukuba, Ibaraki, Japan, 15-19 Jul 2003, Nucl. Phys. Proc. Suppl. **129** (2004) 754 [hep-lat/0309015]. **Joint Valencia–Marseille–DESY/Zeuthen.**

27. H. Czyż, A. Grzelińska, J. H. Kühn and G. Rodrigo, *Perspectives for the radiative return at meson factories*, Presented at Workshop on Hadronic Cross-Section at Low-Energy (SIGHAD03), Pisa, Italy, 8-10 Oct 2003, Nucl. Phys. Proc. Suppl. **131** (2004) [hep-ph/0312217]. **Joint Valencia-DESY/Karlsruhe–Warsaw/Katowice.**

28. J. Bijnens and P. Talavera, *$K_{\ell 3}$ at two loops in ChPT*, Presented at Chiral Dynamics 2003 Theory and Experiment Bonn/Germany, 8-13 Sep 2003. **Joint Barcelona–Lund.**

29. J. Bijnens, E. Gamiz and J. Prades, *Hadronic matrix elements for kaons*, Invited talk at 10th International QCD Conference (QCD 03), Montpellier, France, 2-9 Jul 2003. Nucl. Phys. Proc. Suppl. **133C** (2004) 245 [hep-ph/0309216]. **Joint Barcelona/Granada–Lund.**

30. F. Cornet, P. Jankowski and M. Krawczyk, *CJK improved LO parton distributions in the real photon and their experimental uncertainties*, Proc. Photon2003: International Conference on the Structure and Interactions of the Photon and 15th International Workshop on Photon-Photon Collisions, Frascati, Italy, 7-11 Apr 2003, Nucl. Phys. Proc. Suppl. **126** (2004) 28 [hep-ph/0310029]. **Joint Barcelona/Granada–Warsaw.**

31. M. Awramik, M. Czakon, A. Freitas and G. Weiglein, *Two-loop fermionic electroweak corrections to the effective leptonic weak mixing angle in the standard model*, 7^{th} DESY Workshop on Elementary Particle Theory, Loops and Legs in Quantum Field Theory, April 25-30, 2004, Zinnowitz (Usedom Island), Germany, to appear in Nucl. Phys. Proc. Suppl. **B** [hep-ph/0408207]. **Joint Durham–DESY/Zeuthen.**

32. F. Jegerlehner, K. Kołodziej and T. Westwanski, *Towards precise predictions for the Higgsstrahlung at a linear collider*, 7^{th} DESY Workshop on Elementary Particle Theory, Loops and Legs in Quantum Field Theory, April 25-30, 2004, Zinnowitz (Usedom Island), Germany, to appear in Nucl. Phys. Proc. Suppl. **B** [hep-ph/0407071]. **Joint DESY/Zeuthen–Warsaw/Katowice.**

1.2.3 Preprints

1. R. M. Godbole, A. Grau, G. Pancheri and Y. N. Srivastava, *Soft gluon radiation and energy dependence of total hadronic cross-sections*, hep-ph/0408355. **Joint INFN–Barcelona.**

2. 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. **B** submitted, hep-ex/0407048. **Joint INFN–DESY/Karlsruhe.**

3. S. Miscetti *et al.* [KLOE Collaboration], *Highlights of the KLOE experiment at $DA\Phi NE$*, hep-ex/0405040. **Joint INFN–DESY/Karlsruhe.**

4. E. Gámiz, M. Jamin, A. Pich, J. Prades, F. Schwab, *V_{us} and m_s from hadronic tau decays*, hep-ph/0408044. **Joint Valencia–Granada.**

5. L. Giusti, P. Hernández, M. Laine, P. Weisz, H. Wittig, *A strategy to study the role of the charm quark in explaining the $\Delta I = 1/2$ rule*, hep-lat/0407007. **Joint Valencia–Marseille.**

6. H. Czyż, A. Grzelińska, J. H. Kühn and G. Rodrigo, *The radiative return at Φ and B factories: fsr for muon pair production at next-to-leading order*, hep-ph/0404078. **Joint Valencia-DESY/Karlsruhe–Warsaw.**

7. F. Cornet, P. Jankowski and M. Krawczyk, *A new 5 flavour NLO analysis and parametrizations of parton distributions of the real photon*, Phys. Rev. **D** in print, hep-ph/0404063. **Joint Barcelona/Granada–Warsaw.**

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

9. S. Dürr, C. Hölbling and U. Wenger, *Staggered eigenvalue mimicry*, hep-lat/0406027. **Joint Marseille–DESY/Zeuthen.**

10. S. Dürr and C. Hölbling, *A comparative study of overlap and staggered fermions in the Schwinger model*, hep-lat/0408039. **Joint Marseille–DESY/Zeuthen.**

11. J. Hirn and J. Stern, *Anomaly-matching and Higgs-less effective theories*, hep-ph/0403017. **Joint Orsay–Durham.**

12. M. Awramik, M. Czakon, A. Freitas and G. Weiglein, *Complete two-loop electroweak fermionic corrections to* $\sin^2\Theta^{\rm lept}_{\rm eff}$ *and indirect determination of the Higgs boson mass*, Phys. Rev. Lett. (submitted for publication), hep-ph/0407317. **Joint Durham–DESY/Zeuthen.**

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, C. Smith, R. Unterdorfer, " The Rare Decay $K_L \to \pi^0\mu^+\mu^-$ within the SM" April 2004, e-Print Archive: hep-ph/0404127
- Christopher Smith , "Recent progress on the rare decay $K_L \to \pi^0\mu^+\mu^-$," Short talk given at DAFNE 2004: Workshop on Physics at Meson Factories, Rome, Frascati, Italy, 7-11 Jun 2004 [hep-ph/0407361].

Rene Unterdorfer : INFN-LNF

- G. Isidori, C. Smith, R. Unterdorfer, " The Rare Decay $K_L \to \pi^0\mu^+\mu^-$ within the SM" Apr 2004, e-Print Archive: hep-ph/0404127
- G. Isidori, R. Unterdorfer, " On the Short Distance Constraints from $K_{L,S} \to \mu^+\mu^-$", Oct 2003. Published in JHEP 0401:009,2004. e-Print Archive: hep-ph/0311084.

Beatrix Hiesmayr : UAB Universitat Autònoma de Barcelona

- A. Bramon, G. Garbarino and B. Hiesmayr, "Quantum marking and quantum erasure for neutral kaons," Phys. Rev. Lett. **92**, 020405 (2004) [arXiv:quant-ph/0306114].
- A. Bramon, G. Garbarino and B. C. Hiesmayr, "Active and passive quantum erasers for neutral kaons," Phys. Rev. A **69**, 062111 (2004) [arXiv:quant-ph/0402212].
- A. Bramon, G. Garbarino and B. C. Hiesmayr, "Quantitative duality and quantum erasure for neutral kaons," eConf **C0309101**, THWP005 (2003) [arXiv:hep-ph/0311232].
- A. Bramon, G. Garbarino and B. C. Hiesmayr, "Quantitative duality and neutral kaon interferometry in CPLEAR experiments," Eur. Phys. J. C **32**, 377 (2003) [arXiv:hep-ph/0307047].
- A. Bramon, G. Garbarino and B. C. Hiesmayr, "Passive quantum erasure for neutral kaons," arXiv:quant-ph/0404086.

Ignazio Scimemi: Universitat de Barcelona

- I. Scimemi, E. Gamiz and J. Prades, "CP violation in kaons: epsilon'(K)/epsilon(K) vs K $\to$ 3pi," arXiv:hep-ph/0405204.
- I. Scimemi, "Hadronic processes and electromagnetic corrections," eConf **C030614**, 008 (2003).
- I. Scimemi, "Hadronic processes and electromagnetic corrections," arXiv:hep-ph/0311321.

Michela Verbeni: UAB - Universidad de Granada

- J. Gasser, B. Kubis, N. Paver and M. Verbeni, "Comments on Radiative K_{l3} Decay",Invited talk at MESON 2004: 8th International Workshop on Meson Production, Properties and Interactions, Cracow, Poland, 4-8 Jun 2004. Submitted to Int.J.Mod.Phys.A. UG-FT-165-04,CAFPE-35-04.

Silvia Necco : CNRS-CPT Marseille

- M. Hasenbusch and S. Necco, "SU(3) lattice gauge theory with a mixed fundamental and adjoint plaquette action: Lattice artefacts," JHEP **0408**, 005 (2004) [arXiv: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.

- S. Necco, "Universality and scaling behavior of RG gauge actions," Nucl. Phys. B **683**, 137 (2004) [arXiv:hep-lat/0309017].

Johannes Hirn : University of Durham

- J. Hirn and J. Stern, " The role of spurions in Higgs-less electroweak effective theories", hep-ph/0401032, Eur.Phys.J. C34:447-475,2004.
- J. Hirn and J. Stern, " Anomaly matching and Higgs-less effective theories", hep-ph/0403017.

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", LU TP 04-26, hep-lat/0406017.

Bruno Julia-Diaz : UH.DPHY University of Helsinki

- B. Julia-Diaz, A. Valcarce, P. Gonzalez and F. Fernandez, "A microscopic $NN \to NN^*(1440)$ potential", Eur. Phys. J. **A19**, s01, 99 (2004) [nucl-th/0310072]
- B. Julia-Diaz, D.O. Riska and F. Coester, " Baryon form factors of relativistic constituent-quark models", Phys. Rev. **C69**, 035212 (2004) [hep-ph/0312169].
- B. Julia-Diaz and D.O. Riska, "Baryon magnetic moments in relativistic quark models", Nucl. Phys. **A739**, 69 (2004) [hep-ph/0401096].
- B. Julia-Diaz and D.O. Riska, " Nuclei of Double-Charm Hyperons", [nucl-th/0405061].
- B. Julia-Diaz, D.O. Riska and F. Coester, " Axial Transition Form Factors and Pion Decay of Baryon Resonances", Phys. Rev. C (accepted for publication) [nucl-th/0406015].
- Jun He, B. Julia-Diaz and Yu-bing Dong, "Electromagnetic form factors of pion and rho in the three forms of relativistic kinematics", [hep-ph/0407043].

Michal Czakon : DESY Zeuthen

- M. Awramik, M. Czakon, A. Freitas and G. Weiglein, " Two-loop fermionic electroweak corrections to the effective leptonic weak mixing angle in the standard model", e-Print Archive: hep-ph/0408207.

- M. Awramik, M. Czakon, A. Freitas and G. Weiglein, " Complete two-loop electroweak fermionic corrections to $\sin^2\Theta^{\rm lept}_{\rm eff}$ and indirect determination of the Higgs boson mass", e-Print Archive: hep-ph/0407317.

- M. Czakon, J. Gluza and T. Riemann, "A complete set of scalar master integrals for massive 2-loop Bhabha scattering: Where we are", e-Print Archive: hep-ph/0406203.

- M. Awramik, M. Czakon, A. Freitas and G. Weiglein, "Precise prediction for the W-boson mass in the standard model, Published in Phys. Rev. D **69** (2004) 053006, e-Print Archive: hep-ph/0311148.

Bastian Kubis : University of Bern

- J. Gasser, B. Kubis, N. Paver and M. Verbeni, "Comments on Radiative K_{l3} Decay",Invited talk at MESON 2004: 8th International Workshop on Meson Production, Properties and Interactions, Cracow, Poland, 4-8 Jun 2004. Submitted to Int.J.Mod.Phys.A. UG-FT-165-04,CAFPE-35-04.

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 $\surd$ to indicate the involvement of the groups during the first year of operation (see First Periodic Report) and a $\bullet$ for the involvement during the second year of operation. Notice that the last two columns in Table 2 have been more generally labelled to include items related to the given task. Thus, the column α_s *in the infrared* includes now also *Structure functions* and *glueballs spectroscopy* includes the study of scalar mesons and the newly observed (but not yet fully confirmed) pentaquark state. ¿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 on.

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

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

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

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 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.

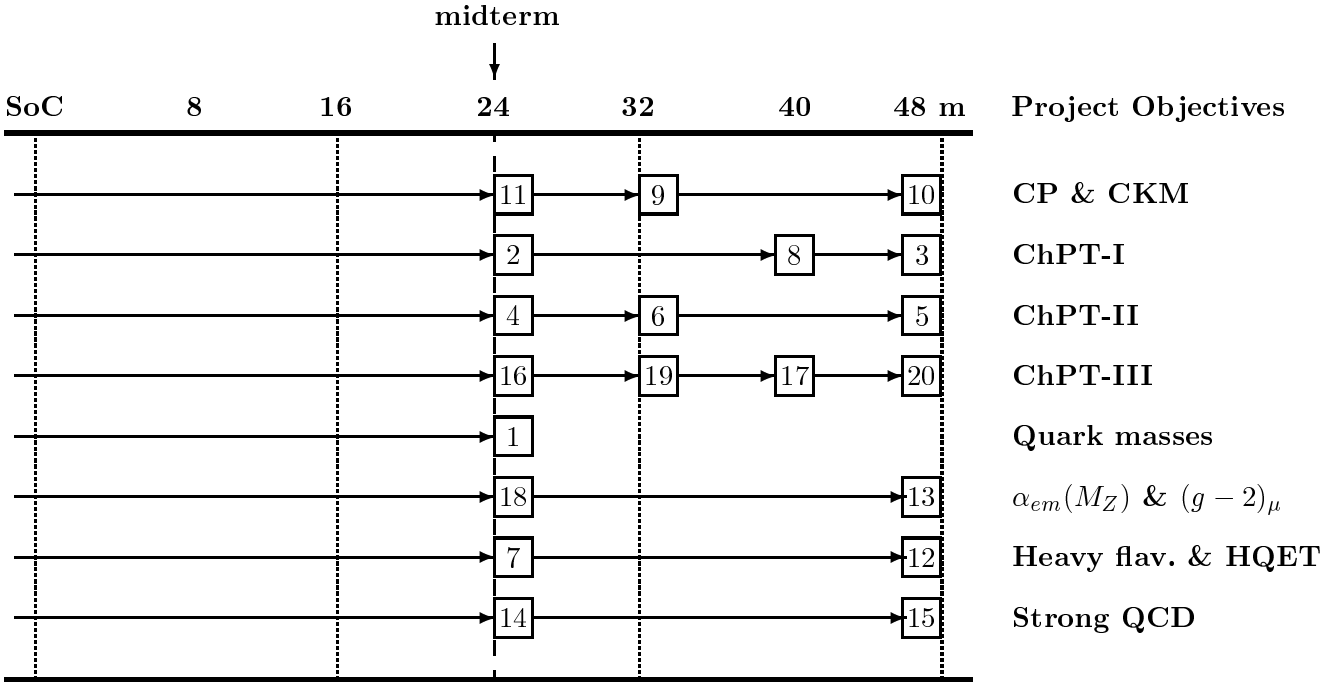
Table 4: EURIDICE Research Effort after 2 years of operation: Columns (c) and (d) include also the young researchers financed by the Contract

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 31/08/04		Total Researchers financed from all sources (person-months)/year (c) as in the contract, (d) as of 31/08/04		Researchers contributing to the project (number of individuals) (e) as in the contract, (f) as of 31/08/04	
		(a)	(b)	(c)	(d)	(e)	(f)
1.	INFN	48	23	155	183	30	29
2.	UVEG	30		200	120	19	19
3.	UAB	30	22	222	240	26	28
4.	CNRS DR12	24	11	80	94	12	12
5.	CNRS-IN2P3	24		66	66	12	12
6.	DUR	48	13	60	50	10	9
7.	ULUND	13	11	53	62	6	7
8.	UHELS	13	13	58	55	8	8
9.	DESY Zeuthen	24	11	122	136	13	18
10.	UNIBE	24	23	226	132	13	15
11.	Vienna	24	11	60	60	9	8
12.	Warsaw	0		67	52	11	8
Totals		302	138	1369	1250	169	173

Schedule and Milestones

All the work is proceeding according to the schedule laid out in the Contract, which we reproduce here. The milestones indicated in the original plan had been placed in time for the Midterm Report. Presently the midterm Report is scheduled for February 2005 and we expect to reach the milestones in time for the Mid Term Review Meeting.

EURIDICE Schedule and Milestones



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 $\alpha_{\rm QED}$
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 $\sigma_{\rm had}$ 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 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 second year of operation, two meetings were held, one in Paris, on December 5th 2003, organized by the Paris node, and a second one in February 2004, during the third Collaboration Meeting. The Executive Committee Meetings were concerned with preparation of the Collaboration Meeting (december 2003) and approval of hiring for 2004 and discussion of working groups progress (february 2004). Also planning for the LNF Spring School and for other topical workshops was discussed.

- *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. The details can be found in the reports from the individual nodes, in Annex I. In the following, for brevity, we list only the main International Conferences where members of the network gave invited talks :

  ⋆ Hadron 03: 10th International Conference on Hadron Spectroscopy, Aschaffenburg, Germany, Aug-Sept. 2003

  ⋆ Chiral Dynamics 2003, Bonn, Germany, Sept. 2003

  ⋆ Beauty 2003, Carnegie Mellon, Pittsburg, USA, October 2003

  ⋆ 39 Rencontres de Moriond in La Thuile, 21-28 March 2004

  ⋆ Linear Collider World Study in Paris, April 2004

  ⋆ Meson04, Kraków, June 4-8, 2004.

  ⋆ DAΦNE 2004, 4th International Conference on Meson factories, June 2004

  ⋆ Lattice 2004 Conference at Fermilab, 21-26 June 2004

⋆ BEACH2004, 6th International Conference on Hyperons, Charm and Beauty Hadrons, Illinois Institute of Technology, june 27.-july 3., Chicago, 2004

⋆ QCD 2004 Conference in Montpellier, July 2004

⋆ XXXIV International Symposium on Multiparticle Dynamics, Sonoma County, California, USA, july 26th-August 1st, 2004

⋆ International Conference on High Energy Physics 2004, Beijing, August 2004

⋆ 19th European Few-Body Conference on Problems in Physics, Groningen, The Netherlands, 23-27 Aug 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 second 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 :

- Workshop on Hadronic Cross-section at Low Energy, organized by G. Venanzoni from INFN-LNF and W. Kluge from the Karlsruhe subnode of the DESY-ZEUTHEN node, Pisa, Italy, October 8-10th, 2003.

- Workshop on Hadronic Atoms, organized with the collaboration of the Bern node, Trento (Italy) 13-17 October 2003.

- Third Collaboration Meeting, Vienna, Austria, 12-14 February 2004.

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

- LNF Spring School Bruno Touschek, Frascati May 17-21st 2004.

  Organized by G. Pancheri, attended by approximately 50 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 second year of operation, continuing and expanding the collaboration among nodes. Because of the large number of exchanges and the many varied topics of joint research, it is difficut to list all of them, even in tabular form. However the details can be found in the individual node reports in ANNEX I.

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 second 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 90 % of all the positions available are filled, with 273 person-months committed for hiring of young researchers. 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-48 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

****

Stratos Tstatis

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

March 2nd, 1978

Greek

April 30th 2004

3 months

****

Stephanie Trine

Post-doc

June 23rd, 1974

Belgian

October 1st 2004

12 months

2. Universidad de Valencia : 30 months in contract- 23 months committed

   Johannes Hirn

   Post-doc

   Birthdate: 3-10-1977

   French

   Starting date: 1 October 2004

   23 months (+1 outside Euridice)

3. UAB Universitat Autònoma de Barcelona : 30 months in contract-32 months committed

   Name: Beatrix C. Hiesmayr.

   Post-doc.

   Birthdate: Jan. 27th, 1975.

   Austrian.

   Feb. 1st, 2003.

6 months.

****

Ignazio Scimemi

Post-doc

September 9th, 1969

Italian

October 1st, 2003

6 months

****

Michela Verbeni

Post-doc

June 16th, 1970

Italian

November 1st, 2003

20 months

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

   Juan Jose Sanz-Cillero

   Post-doc

   Date of birth : October 6th, 1976

   Spanish

   Start of appointment : October 1st 2004

   23 months

6. U. of Durham : 48 months in contract-26 months committed

   Johannes Hirn

   PhD Student

   Date of birth : October 3rd, 1977

   French

   Start of appointment : October 1st, 2003

12 months

****

Kamel Benhaddou

PhD Student

Date of birth : November 20th, 1973

French

Start of appointment : October 1st, 2003

2 months

****

Laura Edera

Post-doc

Date of birth : February 2nd, 1975

Italian

Start of appointment : November 1st, 2004

12 months

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

   Timo Lähde

   Post-doc

   July 30, 1977

   Finnish

   October 1st 2003

   24 months

   Note : The above 24 months refer to the possibility to obtain a tax free status for the young resrarcher, in which case it may be possible to use EU funding for support for 24 months.

8. U. of Helsinki : 13 months in contract-16,5 months committed

   Bruno Julia-Diaz

   Post-doc

   September 13th, 1975

   Spanish

   June 1st 2003

   13 month (16,5 months)

   Note : For the duration, the number (13 months) is the one from contract. The Helsinki node will cover additional 3,5 months from local sources (the 16,5 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-23 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

All the young researchers so far have been fully integrated in the research programme, some of them have already published their results in reeereed journals, most of them in the form of electronic preprints and the relative papers have been submitted for publication in the international journals.

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, paticipation and attendance to the Collaboration Meeting and partecipation to the topical Workshops dedicated to the research topic 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 17 young researchers being trained so far, 5 of them are women, representing a proportion of 29%, higher what is usualy 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).

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 and changes w.r.t the contract

No difficulties have been reported. A change in the distribution of funds has been reported by the Hensinki node, upon agreement with the EU Officer in charge. Dr. Bruno Julia-Diaz, Spanish, joined the group starting from June 2nd, 2003 with an expected stay of 16.5 months whereof 13 months were covered by the EU grant, the rest covered by sources than the contract. Some remaining funds in the "Young researcher" category were tranfered to "Networking" category with the permission of the Commission because the remaing money after 13 months would not cover one additional full month. This did not constitute a detriment to the young researcher, and was not causing a substantial reduction of the personnel costs to get anywhere close to the 60 % limit.

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 01/09/2004 (person-months)
	(a)	(b)	(a+b)	(c)	(d)	(c+d)	
1.INFN-LNF	24	24	48	R. Unterdorfer 9 S. Tsatis 3	C. Smith 11	23	C. Smith 13 S.Trine 12
2.UVEG		30	30				J. Hirn 23
3.UAB		30	30		B. Hiesmayr 6 I. Scimemi 6 M. Verbeni 10	22	M. Verbeni 10
4.CNRS-DR12		24	24		S. Necco 11	11	S. Necco 13
5.CNRS/IN2P3		24	24				J. J. Sanz-Cillero 23
6.DUR	24	24	48	J. Hirn 11 K. Benhaddou 2		13	J. Hirn 1 L. Edera 12
7.ULUND		13	13		T. Lähde 11	11	T. Lähde 13
8.UHELS		13	13		B. Julia-Diaz 13	13	
9.DESY Zeuthen		24	24		M. Czakon 11	11	M. Czakon 13
10.UNIBE		24	24		B.Kubis 23	23	
11.UWIEN.IT		24	24		R. Kaiser 11	11	R. Kaiser 13
TOTAL	48	254	302	25	113	138	135

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

SCIENTIFIC STAFF

LNF: **Giulia Pancheri** (100%), G. Isidori (70%), J. Lee-Franzini (50%),Simona Giovannella (35%), Fabio Bossi (30%), F. Mescia (100% Post-doc), E. Nardi (30%), C. Smith (100% Post-doc), R. Unterdorfer (100% Ph.D. St.); Bari: P. Colangelo (70%), F. De Fazio (70%); R. Ferrandes (100% Post-doc); A. Polosa (50% post-doc) Bologna: M. Caffo (50%), E. Remiddi (50%); S. Laporta (50%); Naples: G. D'Ambrosio (100%); Perugia: O. Panella (30%), Y. Srivastava (30%), M. Cannoni, S. Pacetti (50% Post-docs); Rome1: C. Bini (35%), P. Franzini (50%); Rome-III: F. Nguyen (100% Post-doc.); Trieste: F. Benatti (10%), R. Floreanini (10%), N. Paver (40%); Torino: W. Alberico (10%), G. Garbarino (25%), A. Molinari (10%).

Total: 29 researchers ≡ 183 p-m/y

Scientific Highlights

- *CKM matrix, CP violation and rare decays*
  The LNF group, in collaboration with external members from Rome universities, has presented a new high-precision study of the $K \to \pi$ form factor, relevant for the extraction of the CKM matrix element V_{us}. The analysis is performed combining Lattice QCD and CHPT techniques.
  A new study of the rare decay $K_L \to \pi^0\mu^+\mu^-$ within CHPT, performed by a joint LNF-Wien collaboration, has demonstrated that also this mode can be used (in the future) to perform precision tests of short-distance dynamics in $\Delta S = 1$ transitions.

- $(g-2)_\mu$ *and multi-loop calculations.*
  The Bologna group, in collaboration with the Karlsruhe and Warsaw nodes, has continued an intense activity about analytic and/or numeric evaluations of multi-loop amplitudes: i) two loop (and more) analytic calculations for Bhabha scattering and others QED quantities; ii) two loop analytic corrections to QCD quantities; iii) two loop precise numerical evaluations (even on thresholds) of a selfmass with arbitrary masses from differential equations.

- *Heavy-quark systems and scalar mesons.*
  The researchers of the Bari group have performed new studies on the following subjects: i) newly discovered positive parity charmed mesons; ii) deviations from factorization in nonleptonic B decays to charmonium; iii) rescattering effects in B decays to two light vector mesons and of their role in determining the polarization fractions.

- *Strong QCD limit*
  The LNF and Perugia groups, in collaboration with the Granada team from Barcelona node, has continued to investigate the energy dependence of all total cross-sections through the soft-gluon resummation and singular α_S formalism developed in earlier work. A new study of the proton-proton and antiproton cross-section was performed.

- *Hypernuclear Physics*
  The activity of the Torino group has been focused on: i) evaluation of nucleon coincidence observables in the non-mesonic weak decay of Lambda-hypernuclei; ii) analyses

of recent KEK coincidence data and determination of the Γ_n/Γ_p ratio for ${}^{5}_{\Lambda}$He and ${}^{12}_{\Lambda}$C; calculation of proton asymmetries in the non-mesonic weak decay of polarized Lambda-hypernuclei.

- *Experimental progress of KLOE.*
  In the last 12 months, the KLOE collaboration has performed several new measurements of K decays, radiative Φ decays and low-energy hadronic cross sections analyzing the 450 pb^{-1} collected during 2001-2002 running. A new data taking has started on May 2004 and the experiment is expected to collect 2 fb^{-1} in the coming year. The most significant analysis results can be summarized as follows:

  1. finalized measurement of the pion form factor using the radiative return method, and the related evaluation of the hadronic contribution to $(g-2)_\mu$ with a systematic error of 0.9%(exp) $\otimes$ 0.9 %(theory).
  2. preliminary measurement of branching ratios, BR, for all main K_L decay modes via K_L tagging. The BR measurement for $K_L \to \pi^\pm e^\mp \nu$ and $K_L \to \pi^\pm \mu^\mp \nu$, together with a new determination of the K_L lifetime, are relevant for the extraction of the CKM element $|V_{us}|$;
  3. updated results on branching ratios and charge asymmetry of $K_S \to \pi^\pm e^\mp \nu$ decays (relevant both for V_{us} and for CPT tests);
  4. upper bound on the rare $K_S \to 3\pi^0$ decay (relevant for CP and CPT tests);
  5. for radiative Φ decays there are updated results on $\Phi \to \eta'\gamma,\ f^0(980)\gamma,\ a^0(980)\gamma$ and brand new measurements such as: study of the dalitz-plot distributions for $\eta \to 3\pi$ decays, search for the rare decay $\eta \to \pi^0\gamma\gamma$ and upper-limits for the $\eta \to \pi^+\pi^-$ process. A first observation of the $f^0(980) \to \pi^+\pi^-$ decay has also been obtained by studying the $M(\pi^+\pi^-)$ spectrum in the $\pi^+\pi^-\gamma$ final state with large angle photons.

  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 the LNF Spring School in May 2004. In addition two meetings of interest to the EURIDICE work have been organized, the Alghero Workshop on e^+e^- *in the 1-2 GeV Range*, in September 2003, and *DAΦNE 2004: Physics at Meson Factories*, in june 2004, in Frascati. Both meetings were attended by various members of the network.

Travel Expenditures

G. Pancheri, travel to MIT, Boston, for field trip physics discussions, August 2003
F. Nguyen, travel to Bonn for Chiral Dynamics 2003, september 2003
R. Unterdorfer, travel to Bonn for Chiral Dynamics 2003, september 2003
M. Caffo, travel to Karlsruhe for networking, october 2003
G. Pancheri, travel to Paris for Executive Committe Meeting, december 2003

C. Smith, travel to Louvain, for scientific discussions at home institution, december 2003-january 2004
G. Pancheri, travel to Vienna for Collaboration Meeting, february 2004
G. Isidori, travel to Vienna for Collaboration Meeting, february 2004
C. Smith, travel to Vienna for Collaboration Meeting, february 2004
Y.N. Srivastava, travel to Orsay, Paris, for networking, february 2004
F. De Fazio,travel to Vienna for Collaboration Meeting, february 2004
R. Unterdorfer,travel to Vienna for Collaboration Meeting, february 2004
G. Isidori, travel to Bern for networking, april 2004

Joint Publications

1. W. M. Alberico, G. Garbarino, A. Parreno and A. Ramos, *Towards a solution of the Γ_n/Γ_p puzzle in the weak decay of Lambda hypernuclei*, nucl-th/0407046, **joint INFN-Barcelona**.

2. R. Bonciani, P. Mastrolia and E. Remiddi, *Master integrals for the 2-loop QCD virtual corrections to the forward-backward asymmetry*, Nucl. Phys. B **690**, 138 (2004) [hep-ph/0311145], **joint INFN-DESY/Karlsruhe**.

3. R. Bonciani, A. Ferroglia, P. Mastrolia, E. Remiddi and J. J. van der Bij, *Planar box diagram for the (N(F) = 1) 2-loop QED virtual corrections to Bhabha scattering*, Nucl. Phys. B **681**, 261 (2004) [hep-ph/0310333], , **joint INFN-DESY/Karlsruhe**.

4. A. Bramon, G. Garbarino and B. C. Hiesmayr, *Active and passive quantum erasers for neutral kaons*, Phys. Rev. A **69**, 062111 (2004) [quant-ph/0402212], **joint INFN-Barcelona**.

5. M. Caffo, H. Czyz, A. Grzelinska and E. Remiddi, *Numerical evaluation of the general massive 2-loop 4-denominator self-mass master integral from differential equations*, Nucl. Phys. B **681**, 230 (2004) [hep-ph/0312189], **joint INFN-Warsaw**.

6. P. Colangelo, F. De Fazio and T. N. Pham, *The riddle of polarization in $B \to VV$ transitions*, Phys. Lett. B **597**, 291 (2004) [hep-ph/0406162], **joint INFN-Paris**.

7. P. Colangelo, F. De Fazio and T. N. Pham, *Nonfactorizable contributions in B decays to charmonium: The case of $B \to K - h/c$*, Phys. Rev. D **69**, 054023 (2004) [hep-ph/0310084], **joint INFN-Paris**.

8. A. Ghinculov, T. Hurth, G. Isidori and Y. P. Yao, *The rare decay $B \to X_s \ell^+ \ell^-$ to NNLL precision for arbitrary dilepton invariant mass*, Nucl. Phys. B **685**, 351 (2004) [hep-ph/0312128], **joint INFN-Bern/Zurich**.

9. A. Ghinculov, T. Hurth, G. Isidori and Y. P. Yao, *New NNLL QCD results on the decay $B \to X_s \ell^+ \ell^-$*, Eur. Phys. J. C **33**, S288 (2004) [hep-ph/0310187], **joint INFN-Bern/Zurich**.

10. R. M. Godbole, A. Grau, G. Pancheri and Y. N. Srivastava, *Soft gluon radiation and energy dependence of total hadronic cross-sections*, hep-ph/0408355, **joint INFN-Barcelona**.

11. R. M. Godbole, A. Grau, G. Pancheri and Y. N. Srivastava, *Photon total cross-sections*, Nucl. Phys. Proc. Suppl. **126**, 94 (2004) [hep-ph/0311211], **joint INFN-Barcelona**.

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21. A. G. Denig *et al.* [KLOE Collaboration], *KLOE perspectives for R-measurements at DAPHNE2*, eConf **C0309101**, FRWP009 (2003) [hep-ex/0403005], **joint INFN-DESY/Karlsruhe**.

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26. A. Di Domenico *et al.* [KLOE Collaboration], *Kaon interferometry at KLOE: Present and future*, eConf **C0309101**, THWP007 (2003) [hep-ex/0312032], **joint INFN-DESY/Karlsruhe**.

27. S. Di Falco [KLOE Collaboration], *Latest results from DAPHNE*, Acta Phys. Polon. B **34**, 5207 (2003) [hep-ex/0311006], **joint INFN-DESY/Karlsruhe**.

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Other Publications

1. D. Becirevic *et al.*, *The $K \to \pi$ vector form factor at zero momentum transfer on the lattice*, submitted to Nucl. Phys. B, hep-ph/0403217.

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9. F. De Fazio, *Nonfactorizable effects in B to charmonium decays*, Eur. Phys. J. C **33**, S247 (2004) [hep-ph/0310171].

10. F. De Fazio, *On the coupling g(f0 K+ K-) and the structure of f0(980)*, Eur. Phys. J. C **33**, S560 (2004) [hep-ph/0310170].

11. R. Ferrandes, *Interpretation of D/sJ*(2317) and D/sJ*(2460)* Talk given at 16th Conference on High Energy Physics (IFAE 2004), Turin, Italy, 14-16 Apr 2004, hep-ph/0407212.

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13. G. Isidori, *Theory of radiative and rare B decays,* hep-ph/0401079.

14. G. Isidori, *Summary and overview of working group VI: V_{us} and V_{ud},* eConf **C0304052**, WG601 (2003) [hep-ph/0311044].

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16. S. Laporta and E. Remiddi, *Analytic treatment of the two loop equal mass sunrise graph*, hep-ph/0406160.

17. G. Pancheri, Y. Srivastava and N. Staffolani, *Sum rules for hadronic elastic scattering for the Tevatron, RHIC and LHC*, hep-ph/0406321.

18. E. Remiddi, *Differential equations for the 2-loop equal mass sunrise*, Acta Phys. Polon. B **34**, 5311 (2003) [hep-ph/0310332].

19. O. Shekhovtsova, S. Dubinsky, A. Korchin, N. Merenkov and G. Pancheri, *Final-state radiation in electron positron annihilation into pion pair*, hep-ph/0408151.

3.2 University of Valencia

Participant Number 2 : UVEG University of Valencia

SCIENTIFIC STAFF

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%)
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 :

- Study of $\tau^- \to (\pi\pi\pi)^-\nu_\tau$ within the framework of the Resonance Effective Theory of QCD.
- Evaluation of the isospin breaking corrections to the CP–direct observable ε'/ε.
- Phenomenological study of the $\langle VAP\rangle$ 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.
- Analysis, within Chiral Perturbation Theory, of the role of the charm flavour in the $\Delta I = 1/2$ rule of non-leptonic kaon decays.
- Non–perturbative renormalization of coupling constants on the lattice.
- Study of radiative decays of the ϕ meson and their comparison with KLOE (DAPHNE) data.
- Evaluation of the decay rates of $J/\psi \to PP\,(\phi,\omega)$ and $J/\psi \to \pi\pi\, p\overline{p}$, where P is short for pseudoscalar meson.
- Study of the dynamical generation of baryonic resonances and consequent description of many known and new resonances. Several of the later ones are under investigation in some Laboratories. In particular a resonance of positive strangeness coming from $\Delta\, K$ interaction in $I = 1$ is predicted.
- Analysis of pentaquark states to determine spin and parity of the Θ^+, its possible origin as a $K\pi N$ bound state and the existence of hypernuclei of Θ^+.

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 and evaluation of the contributions of resonances to the coupling constants of the $\mathcal{O}(p^6)$ Chiral Perturbation Theory Lagrangian.

- 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.

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

- Evaluation of the Resonance Effective Theory at one–loop through functional integration: a) divergent pieces, b) finite part up to two propagators.

- Study of pentaquark states. We plan to explore the possibility of the existence of exotic states which qualify as quasi bound states of meson-baryon or two mesons and a baryon (heptaquark), Θ^+ hypernuclei. Moreover the role of two meson cloud in the nature of the Θ^+ and other members of the assumed antidecuplet of baryons will be studied.

- Dynamical generation of axial–vector mesons through the study of the interaction of pseudoscalar and vector mesons.

- Analysis of the precise determination of the pion nucleon scattering lengths from pion nucleon scattering, pion hydrogen atom and pion deuteron atoms.

- Calculations of different reactions to analyse the modifications of ϕ properties in the nuclear medium.

Networking

- Participation of J. Portolés in the Workshop of Hadronic Cross Section at Low Energy, (Pisa, 8-10th October 2003).

- Participation of the Valencia group in the Third EURIDICE Collaboration Meeting (Vienna, 12-14th February 2004): A. Pich, E. Oset, M. Vicente-Vacas, D. Cabrera, L. Roca, J.J. Sanz-Cillero, M. Eidemüller, J.A. Oller, J. Portolés.

- J. Portolés visited the Vienna node for two weeks in February 2004.

- G. Ecker and R. Kaiser (Vienna) visited the Valencia node for two weeks in April 2004.

- Participation of I. Rosell and V. Mateu in the LNF Spring School Bruno Touschek (Frascati, 17-21st May 2004).

- I. Rosell visited the Vienna node for two months (May-June 2004).

Joint Publications

Valencia-Marseille (France)

- P.H. Damgaard, P. Hernández, K. Jansen, M. Laine, L. Lellouch, "Vector and axial vector propagators in the epsilon regime of QCD", *Nucl. Phys. Proc. Suppl.* **129** (2004) 754.

- L. Giusti, P. Hernández, M. Laine, P. Weisz, H. Wittig, "Low-energy couplings of QCD from topological zero mode wave functions", *JHEP* **0401:003** (2004).

- L. Giusti, P. Hernández, M. Laine, P. Weisz, H. Wittig, "Low-energy couplings of QCD from current correlators near the chiral limit", *JHEP* **0404:013** (2004).

- L. Giusti, P. Hernández, M. Laine, P. Weisz, H. Wittig, "A strategy to study the role of the charm quark in explaining the $\Delta I = 1/2$ rule", hep-lat/0407007.

Valencia-Roma (Italy)-Marseille (France)

- V. Giménez, L. Giusti, S. Guerriero, V. Lubicz, G. Martinelli, S. Petrarca, J. Reyes, B. Taglienti, E. Trevigne, "Nonperturbative renormalization in coordinate space", *Nucl. Phys. Proc. Suppl.* **129** (2004) 411.

- D. Becirevic, G. Giménez, V. Lubicz, G. Martinelli, M. Papinutto, J. Reyes, "Renormalization constants of quark operators for the nonperturbatively improved Wilson action", hep-lat/0401033.

- V. Giménez, L. Giusti, S. Guerriero, V. Lubicz, G. Martinelli, S. Petrarca, J. Reyes, B. Taglienti, E. Trevigne, "Non-perturbative renormalization of lattice operators in coordinate space", hep-lat/0406019.

Valencia-Wien (Austria)

- V. Cirigliano, G. Ecker, H. Neufeld, A. Pich, "Isospin breaking in $K \to \pi\pi$ decays", *Eur. Phys. J.* **C33** (2004) 369.

- V. Cirigliano, H. Neufeld, H. Pichl, "K(e3) decays and CKM unitarity", *Eur. Phys. J.* **C35** (2004) 53.

- V. Cirigliano, G. Ecker, M. Eidemüller, A. Pich, J. Portolés, "$\langle VAP \rangle$ Green function in the Resonance Region", *Phys. Lett.* **B596** (2004) 96.

3.3 Universitat Autònoma de Barcelona

Participant Number 3 : UAB Universitat Autònoma de Barcelona

Scientific Staff

UAB: **Albert Bramon** (100%), Ll. Ametller (50%), E. Bagan (50%), R. Escribano (100%), 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%)

Total: 28 researchers ≡ 240 p-m/y

Scientific Highlights

- Quantum Mechanics studies for the neutral kaon system have lead to intereting results to study Bell inequalities and other QM effects.
- New renormalization theorems were found for the VVA correlator in perturbative QCD.
- Progress on the nature of scalar mesons has been made by connecting the Linear Sigma Model with modern ChPT.

Networking

- J. Prades visited University of Lund to continue collaboration with J. Bijnens from 13–08–03 to 20–09–03.
- J. Prades visited Universidad de Murcia to collaborate with J.A. Oller for one week in January 04.
- M. Verbeni visited INFN/Pisa to collaborate with F. Scuri, 7–9 April 2004.
- M. Verbeni visited Universidad de Murcia to collaborate with J.A Oller. 21–23 July 2004.
- M. Verbeni participated in the 8th International Workshop on Meson Production, Properties and Interaction, 4–8 June 2004. Krakow, Poland.
- A. Bramon visited INFN/Turin to collaborate with G. Garbarino, 23–26 April 2004.
- G. Garbarino has been one month (May 2004) in Barcelona collaborating with several groups.

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 Vienna, Krakow, Turin, Frascati and Sardinia, among others.

Training

Vacant positions were publicised in several web sites and around twenty applications were examined. Ignazio Scimemi has already spent his 6 month post-doc position at Barcelona University and stays there for 6 further months. Michela Verbeni is working at Granada University with an 18 months post-doc contract. All the training in our node will then be completed.

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3.4 CNRS-CPT Marseille

Participant Number 4 : CNRS-CPT Marseille, Luminy

SCIENTIFIC STAFF

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%) 35 pm/y

C. Hoelbling (9 m/y, 75%), S. Necco (12 m/y, 100%) (Postdocs) 21 pm/y

V. Cuplov (8 m/y, 70%), D. Greynat (10 m/y, 85%), S. Friot (10 m/y, 85%), N. Garron (10 m/y, 85%) (PhD Students) 38 pm/y

Tot. 94 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 and of heavy quarks. Numerical investigations using lattice QCD, with the implementation of chiral fermions in quenched simulations, have become a substantial part of the group's activities. Analytical tools are however still being developed, like the $1/N_c$–expansion in QCD and the heavy quark effective theory, combined with chiral perturbation theory at long distances and the operator product expansion at short-distances.

LATTICE TOPOLOGICAL SUSCEPTIBILITY

Besides its interest within the pure gauge theory, the topological susceptibility, χ, plays a crucial rôle in the QCD-based explanation of the large mass of the η' meson proposed by Witten and Veneziano (WV) a long time ago. Recent theoretical developments led to the discovery of a fermion operator which preserves an exact chiral symmetry at finite lattice spacing. These developments triggered a breakthrough in the understanding of the topological properties of the YM vacuum and made it possible to give a precise and unambiguous implementation of the WV formula [1]. An investigation of the WV scenario with controlled lattice systematics was performed in Ref. [2, 3], where the topological susceptibility for the SU(3) Yang–Mills theory has been computed by employing the expression of the topological charge density operator suggested by Neuberger fermions. In the continuum limit it is found that $r_0^4\chi = 0.059(3)$, which corresponds to $\chi = (191 \pm 5\ \mathrm{MeV})^4$ if F_K is used to set the scale. This result supports the Witten–Veneziano explanation for the large mass of the η'.

CHIRAL COUPLINGS FROM THE LATTICE

Members of the Marseille, Zeuthen and Valencia nodes have pursued the analytical computation of non-singlet vector and axial vector two-point functions in sectors of fixed topology at NLO in the ϵ-expansion of chiral perturbation theory [4]. The resulting expressions can be used to determine the couplings of the leading order chiral lagrangian from lattice simulations in the finite-size scaling regime of QCD. This was shown in [5], where the low-energy couplings Σ, F in the chiral limit, as well as L_5 were determined from lattice simulations with Ginsparg-Wilson fermions, in a finite volume and in the quenched approximation.

A feature of the ϵ regime is that the QCD low energy constants can be extracted from correlation functions computed in a given topological sector. For this purpose it would be useful to adopt a formulation of lattice SU(3) gauge theory which keeps the system with

a fixed topological index. A first study on a topology conserving gauge action has been performed in [6].

$|\Delta S| = 1$ and $|\Delta S| = 2$ Transitions

The next step is to apply the same techniques to the determination of the low-energy couplings of the weak effective Hamiltonian which describe non-leptonic kaon decays. Very recently a strategy designed to separate several possible origins of the well-known enhancement of the $\Delta I = 1/2$ amplitude in non-leptonic kaon decays was presented [7]. In particular, it seeks to disentangle the contribution of physics at the typical QCD scale (soft-gluon exchange) from the effects at the scale of the charm quark mass. This is achieved by considering QCD with an unphysically light charm quark, so that the theory possesses an approximate $\mathrm{SU}(4)_L \times \mathrm{SU}(4)_R$ chiral symmetry. By computing the relevant operator matrix elements and monitoring their values as the charm quark mass departs from the SU(4)-symmetric situation, the rôle of the charm quark can be assessed. The influence of the charm quark mass in Chiral Perturbation Theory was studied. First results from lattice simulations in the SU(4)-symmetric limit were also reported.

In order to validate Neuberger fermions as a useful phenomenological tool, Refs. [8, 9] report on the first calculation with this new fermion formulation of the simpler $\Delta S = 2$ matrix element required for describing indirect CP violation in $K \to \pi\pi$ decays in the standard model. This particular line of work is being extended to $\Delta S = 2$ contributions which appear in extensions of the standard model [10] as well as to electroweak penguin contributions to ϵ' [11, 10].

CKM Matrix

As for the CKM matrix, a full update as well as new analyses taking into account the most recent experimental and theoretical developments have been achieved [12]. The consistency between the Standard Model predictions and the data is very good in most cases, while weak discrepancies can be found in some observables related to the decays of B mesons to charmless particles. However by taking properly into account the theoretical uncertainties, these discrepancies remain below the 2σ level.

Meson and Baryon Spectra

In parallel with the work on weak matrix elements, studies of meson and baryon spectra and "wavefunctions" are being pursued [11, 13]. These will include an investigation of diquark correlations which are thought to play an important rôle in the scalar meson spectrum, the absence of a number of theoretically allowed exotic hadrons, and the possible existence of pentaquarks.

The program on phenomenological applications of Large–Nc QCD which has been undertaken by the CPT group in collaboration with the Univ. Auton. of Barcelona, has been pursued in several directions.

$K \to \pi\bar{l}l$ Decays

The work published in [14] consists of an updated discussion of $K \to \pi\bar{l}l$ decays in a combined framework of chiral perturbation theory and Large–N_c QCD, which assumes the dominance of a minimal narrow resonance structure in the invariant mass dependence of the $\bar{l}l$ pair. The proposed picture reproduces very well, both the experimental $K^+ \to \pi^+ e^+ e^-$ decay rate and the invariant e^+e^- mass spectrum. The predicted $\mathrm{Br}(K_S \to \pi^0 e^+ e^-)$ is, within errors, consistent with the recently reported result from the NA48 collaboration. Predictions for the $K \to \pi\ \mu^+\mu^-$ modes are also obtained. We find that the resulting interference between the *direct* and *indirect* CP–violation amplitudes in $K_L \to \pi^0 e^+ e^-$ is constructive.

The work reported upon in [15] presents a new study of the correlation function of a $V-A$ current with a $V+A$ current discussed within the framework of QCD in the limit of a large number of colours N_c. Applications to the evaluation of chiral condensates of dimension six and higher, as well as to the matrix elements of the Q_7 and Q_8 electroweak penguin operators are discussed and compared with previous determinations of the same parameters. $\langle VV-AA\rangle$

The higher order contributions from hadronic vacuum polarization to the muon $g-2$ have been reanalyzed (D. Greynat, S. Friot and E. de Rafael). A simple way of explaining the negative sign of this contribution was found, as well as a good estimate from simple evaluations of asymptotic behaviours. This work, which will be published in the near future, will also be part of the PhD theses of Samuel Friot and of David Greynat. MUON $g-2$

The scalar exchange contribution to the hadronic light-by-light was reexamined (M. Knecht and M. Perrottet) within a large-N_C inspired approach. Its sensitivity to various properties of the scalars (mass, width, mixing angle) were studied. These results are being prepared for publication.

Non renormalization theorems involving the transverse, i.e. non anomalous, part of the QCD three point function $\langle VVA\rangle$, which describes two loop electroweak corrections to the muon $g-2$, were proven [16]. Some of their consequences and questions they raise were discussed.

L. Lellouch was a convenor at the two "Workshops on the CKM Unitarity Triangle" (CERN 2002-2003 and Durham 2003) to which a large number of members of the network participated. The goal of the workshops was to bring together theorists and experimentalists in different fields to study the determination of the CKM matrix from all the available data of K, D and B physics [17, 18]. CONFERENCES

In April 2004, with members of the Orsay node, L. Giusti and L. Lellouch co-organized the workshop entitled "Lattice QCD: Present and Future" whose final report is available on [19]. Its aim was to provide a review of the many applications to flavor physics and other fields of lattice field theory methods, in view of making a request for what is meant to become a dedicated European supercomputer facility.

L. Giusti gave an invited talk [20] at the International Europhysics Conference on High-Energy Physics (HEP 2003), Aachen, Germany, 17-23 Jul 2003. Several members (L. Giusti, C. Hoelbling, L. Lellouch, S. Necco) of the team attended the Lattice 2004 Conference at Fermilab, 21-26 June 2004, and gave presentations on their work [3, 6, 10, 13]. L. Lellouch gave invited reviews at the 39 Rencontres de Moriond in La Thuile, 21-28 March 2004, and at the Institute for Nuclear Theory in Seattle, Program 04-1 on *QCD and dense matter: from lattices to stars*, 29 March - 19 June 2004.

J. Charles was a member of the Local Organizing Committee of the conference "Flavor Physics and CP Violation" (Paris, 2003). He also gave an invited lecture on CP Violation and B physics at the XXXV Ecole de Gif (Saclay, 2003).

M. Knecht gave invited talks at the Chiral Dynamics Workshop in Bonn, 8-13 September 2003 [21], and at the DAΦNE 2004 Conference [22] in Frascati, 7-11 June 2004, as well as at the Benasque Workshop *Matching Light Quarks to Hadrons*, 25 July - 13 August 2004.

E. de Rafael gave invited talks at the DAPHNE-2 Workshop in Alghero, 10-13 September 2003, and at the Benasque Workshop *Matching Light Quarks to Hadrons*, 25 July - 13 August 2004.

D. Greynat and S. Friot gave presentations at the QCD 2004 Conference in Montpellier (July 2004), and together with J. Charles, at the French Particle Phenomenology Meeting in Lyon (March 2004). S. Friot also gave a talk at the NA48 Mini Workshop at CERN in May 2004.

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

A large fraction of the team (J. Charles, S. Friot, N. Garron, D. Greynat, M. Knecht, S. Necco, E. de Rafael) has attended the 3rd EURIDICE Collaboration Meeting held in Vienna, 12-14 February 2004. All participants of the Marseille node have given a presentation of their work at this meeting.

J. Hirn has visited CPT twice for discussions and seminars.

Training

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

D. Greynat, S. Friot and S. Necco have attended the IX Frascati Spring School in Nuclear, Subnuclear and Astroparticle Physics in May 2004, where they also gave a presentation of their current research work.

N. Garron attended the course on *Lattice QCD and Parallel Computing* at the Bielefeld - Paris-Sud International Graduate School in Orsay, March 2004, where he also gave a presentation of his work.

References

[1] L. Giusti, G. C. Rossi and M. Testa, Phys. Lett. B **587** (2004) 157 [arXiv:hep-lat/0402027].

[2] L. Del Debbio, L. Giusti and C. Pica arXiv:hep-th/0407052

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[6] **S. Shcheredin, W. Bietenholz, K. Jansen, K.-I. Nagai, S. Necco, L. Scorzato**, hep-lat/0409073

[7] **L. Giusti, P. Hernandez, M. Laine, P. Weisz and H. Wittig**, arXiv:hep-lat/0407007.

[8] N. Garron, L. Giusti, C. Hoelbling, L. Lellouch and C. Rebbi, Phys. Rev. Lett. **92** (2004) 042001 [arXiv:hep-ph/0306295].

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

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[12] J. Charles, A. Höcker, H. Lacker, S. Laplace, F.R. Le Diberder, J. Malclès, J. Ocariz, M. Pivk, L. Roos, *CP Violation and the CKM Matrix: Assessing the Impact of the Asymmetric B Factories*, submitted to Eur. Phys. J. C [arXiv:hep-ph/0406184].

[13] F. Berruto, N. Garron, C. Hoelbling, L. Lellouch, C. Rebbi and N. Shoresh, arXiv:hep-lat/0409132.

[14] S. Friot, D. Greynat, and E. de Rafael, Phys. Lett. **B595** (2004) 301.

[15] S. Friot, D. Greynat, and E. de Rafael, arXiv:hep-ph/0408281.

[16] **M. Knecht, S. Peris, M. Perrottet, and E. de Rafael**, **JHEP03** (2004) 035.

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

[18] L. Lellouch, eConf **C0304052** (2003) WG119 [arXiv:hep-ph/0310265].

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[20] L. Giusti, arXiv:hep-ph/0312006.

[21] M. Knecht, in arXiv:hep-ph/0311212.

[22] M. Knecht, arXiv:hep-ph/0409089.

Author names in boldface indicate joint publications

3.5 CNRS-IN2P3 Orsay

Participant Number 5 : CNRS-IN2P3 Orsay, Paris

SCIENTIFIC STAFF

Jan Stern (75%), Bachir Moussallam (75%), Saro Ong (25%), Hagop Sazdjian (50%), Johannes Hirn (Ph.D. Student) (50% during the 1st year) - (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%) F. Jugeau (temporary lecturer) (50% during the 2nd year) - (LPT - Orsay); T.N. Pham (50%) - (CPhT - Ecole Polytechnique);

Total: 12 researchers ≡ 66 p-m/y (average 5.5 p-m/y)

Scientific Highlights

- The heavy-quark limit of QCD

  HEAVY-FLAVOUR DECAYS

  i) A systematic study of Bjorken-like sum rules in the heavy quark limit of QCD has been performed [8, 9, 10]. 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 [9, 10, 11, 25]. The method has been extended to non-leading contributions in $1/M_Q$ [12]. Furthermore, the coupling $g_{DD^*\pi}$ has been studied within QCD sum rules [5].

  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" [17, 18, 30]. The radiative decays $B \to V\gamma$ (with V a vector meson) have been considered and factorisation has been proved at one-loop order for the spectator interactions involving the light quark inside the B-meson [19].

- B-decays and CP violation

  CKM MATRIX

  i) The determination of the CKM angle γ through CP asymmetries in three-body B-decays has been investigated for $B^- \to \pi^+\pi^-K^-$ and $B^- \to K^+K^-K^-$ [13, 26, 16], $B^- \to \phi\phi K^-$ with the $\phi\phi$ invariant mass below the charm threshold [15].

  ii) For charmless two-body B-decays, classes of power corrections to the factorisation approach have been considered, which are $1/m_b$ suppressed in the heavy-quark limit. Long-distance "charming-penguin" contributions to the decays $B \to K\pi$ and $B \to \pi\pi$ [1] were analyzed. For decays into a pseudoscalar and a vector mesons, it was shown that power corrections related to annihilation played a significant role [14].

  iii) Non-factorisable contributions due to charmed-meson rescattering were estimated in $B \to \chi_{c0}\, K^-$ [2, 27] and $B \to h_c K$ [3], suggesting significant contributions from such mechanisms. Similar rescattering effects were invoked to explain the large transverse polarisation in $B \to VV$ (V vector meson) observed at Babar and Belle [4].

  Some of these subjects were also developed in the PhD thesis by Claudia Isola, defended in December 2002 at Ecole Polytechnique.

- Bound-state equation in the Wilson-loop approach

  SPECTROSCOPY

  We have investigated 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 behavior and properties of the equation in the non relativistic and ultrarelativistic limits have been studied [20].

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

- Roy-Steiner equations for πK scattering

  EFFECTIVE COUPLING CONSTANTS

  We 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 were treated in the modern way as a boundary value problem. In the range $E < 1\,\mathrm{GeV}$, precise numerical solutions were obtained which make use as input 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 was the region of allowed values for the two S-wave scattering lengths which are significantly constrained by the boundary conditions. We computed a large set of threshold as well as subthreshold expansion parameters. The latter were matched to the ChPT expansion of the amplitude, leading to a number of $O(p^4)$ chiral couplings L_i, in particular the OZI-suppressed L_4 [21, 29].

- Electromagnetic chiral parameters

  A set of sum rules for the electromagnetic chiral parameters which involve QCD four-point correlators were studied. Implications to the construction of an effective Lagrangian for the light resonances with proper QCD constraints and to radiative corrections were considered [22].

- Three-flavour Chiral Perturbation Theory revisited

  ORDER PARAMETERS, QUARK MASSES

  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 $F^2(3)$ (pseudoscalar decay constant) compared to their respective values in the $N_f = 2$ chiral limit [23]. 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 proposed a non perturbative solution of this problem and we apply it to the three-flavour analysis of $\pi\pi$ scattering. We showed that the latest data imply the lower bound for the quark mass ratio $r = m_s/m > 14$ with 95% confidence level [24].

- Effective theories of Higgsless electroweak symmetry breaking

  CHPT, CP-, T- AND CPT-VIOLATING PARAMETERS

  Building upon our expertise on χPT, we reconsidered low-energy effective theories of Higgsless electroweak symmetry breaking. Generic effective theories based on $SU(2)\times U_Y(1)$ symmetry alone differ from the Standard Model at leading order already (oblique parameters, fermion couplings to W and Z, lepton-number violation).

To solve these problems, we considered models with two decoupled sectors, each with its own symmetry group [6]: a strongly-interacting sector providing Goldstone bosons and a massless gauge sector with gauge fields coupled to chiral fermions. Couplings between the two sectors are introduced through non-propagating spurionic fields satisfying covariant constraints. The spurion fields are used as small expansion parameters, in addition to the usual low-energy expansion. Due to the Higgs mechanism, the Goldstone bosons disappear from the spectrum. At leading order in the low-energy and spurionic expansions, the resulting gauge interactions coincide with the Standard Model. For the model with the minimal particle content, higher spurion terms allow for a CKM-like fermion mass matrix and Majorana neutrino masses. We discussed also non-minimal models.

Anomaly-matching constraints on these Higgsless models were investigated [7]. Unlike QCD-like theories, the global symmetries of the underlying theory which operate on the low-energy variables have to be anomaly-free. We found that the trace of B-L over elementary fermions must vanish. Considering the possibility of composite spin-1/2 fermion fields from the strongly-interacting sector, we found that anomaly-matching does not prevent non-standard couplings at the leading order, and that arbitrary total B-L charges are allowed.

These first results indicate that techniques discussed and developed in the network could be applied with profit to the (higher) electroweak scale. These subjects were also developed in the PhD thesis by Johannes Hirn, defended in July 2004 at IPN Orsay.

Networking

- Two members of the Orsay-Paris node (L. Oliver and J. Stern) presented talks at the 1st Euridice Collaboration Meeting held in Frascati (October 2002).

- The Orsay-Paris node organized the 2nd Euridice Collaboration Meeting held on 6-8 February 2003 at IPN Orsay, Université de Paris-Sud.

  The Meeting was attended by 50 participants. There were 30 oral contributions (30' each), from 25 members of our network and 5 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 were 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 and June 2004) visited Ecole Polytechnique and IPN-Orsay to continue this collaboration and to give seminars.

- L. 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, and were discussed during meetings organised by the

network (1st and 2nd Collaboration Meetings, Hadatom2002 in CERN October 02) as well as by e-mail. Computer programs for the dispersive analysis of scalar form-factors have been shared between the Orsay and Lund nodes.

- Johannes Hirn visited Durham in July 2003 to discuss with M. R. Pennington his predoctoral stay at IPPP Durham funded by the network.
- Five members of the Orsay-Paris node (S. Descotes-Genon, B. Moussallam, L. Oliver, H. Sazdjian, J. Stern) presented talks at the 3rd Euridice Collaboration Meeting held in Vienna (February 2004).
- J. Hirn (Durham) visited LPT Orsay (March 2004) and IPN (May 2004) to give seminars. He came several times to IPN to continue his collaboration with J. Stern.
- B. Moussallam visited the Vienna node in June 2004 for discussions and a seminar.
- J. Soto (Barcelona) visited IPN-Orsay in June 2004 to give a talk and have discussions on the quarkonium bound state problem.

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, UK, April 2003
v) J. Hirn: Visit and discussions at Durham, July 2003
vi) B. Moussallam: Chiral Dynamics 2003, Bonn, September 2003
vii) S. Descotes-Genon, B. Moussallam, L. Oliver, H. Sazdjian, J. Stern: 3rd Euridice Collaboration Meeting, Vienna, February 2004.
viii) J. Hirn (Durham): Visit to Orsay, May 2004.

Training

- 3 PhD students (J. Hirn, C. Isola, F. Jugeau) defended their thesis during the two first years of the contract (supervisors : J. Stern, T.N. Pham, H. Sazdjian, respectively).
- J.J. Sanz-Cillero has been hired as a post-doc from October 1st 2004 for 23 months.

Joint publications with other nodes

[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 (2002) 09 4005

[2] P. Colangelo, F. de Fazio and T. N. Pham: "$B^- \to \chi_{c,0} K^-$ decay from charmed meson scattering", Phys. Lett. B542 (2002) 71 (2002)

[3] P. Colangelo, F. De Fazio and T. N. Pham: "Nonfactorizable contributions in B decays to charmonium: The case of $B \to K^- h_c$", Phys. Rev. D69 (2004) 054023 [hep-ph/0310084]

[4] P. Colangelo, F. De Fazio and T. N. Pham: "The riddle of polarization in B → V V transitions", hep-ph/0406162

[5] 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 (2003) 009 [hep-ph/0212177]

[6] J. Hirn and J. Stern, "The role of spurions in Higgs-less electroweak effective theories", Eur. Phys. J. C34 (2004) 447 [hep-ph/0401032]

[7] J. Hirn and J. Stern, "Anomaly-matching and Higgs-less effective theories", hep-ph/0403017

Single publications of the node

[8] 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]

[9] 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) [hep-ph/0210231]

[10] A. Le Yaouanc, L. Oliver and J.-C. Raynal: "Lower bounds on the curvature of the Isgur-Wise function" Phys. Rev. D69, 094022 (2004) [hep-ph/0307197]

[11] F. Jugeau, A. Le Yaouanc, L. Oliver and J.-C. Raynal: "Bounds on the derivatives of the Isgur-Wise function with a non-relativistic light quark" hep-ph/0405234

[12] F. Jugeau, A. Le Yaouanc, L. Oliver and J.-C. Raynal: "Subleading form factors at order $1/m_Q$ in terms of leading quantities using the non-forward amplitude" hep-ph/0407176

[13] 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 (2002) 67

[14] T.N. Pham and G.H. Zhu: "Power corrections in charmless B decays", Phys. Rev.D69 (2004) 114016 [hep-ph/0403213]

[15] S. Fajfer, T.N. Pham and A. Prapotnik: "The $B \to \phi\phi K^-$ decay rate with $\phi\phi$ invariant mass below the charm threshold", Phys. Rev. D69 (2004) 114020 [hep-ph/0401120]

[16] S. Fajfer, T.N. Pham and A. Prapotnik: "CP violation in the partial width asymmetries for $B \to \pi^+\pi^- K^-$ and $B \to K^+ K^- K^-$ decays", hep-ph/0405065

[17] S. Descotes-Genon and C.T. Sachrajda: "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]

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

[19] S. Descotes-Genon and C.T. Sachrajda: "Spectator interactions in $B \to V\gamma$ decays and QCD factorisation", Nucl. Phys. B693 (2004) 103 [hep-ph/0403277]

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

[21] P. Büttiker, S. Descotes-Genon and B. Moussallam: "A new analysis of πK scattering from Roy and Steiner type equations", Eur. Phys. J. C33 (2004) 409-432 [hep-ph/0310283]

[22] B. Ananthanarayan and B. Moussallam, "Four-point correlator constraints on electromagnetic chiral parameters and resonance effective Lagrangians", JHEP 0406 (2004) 047 [hep-ph/0405206]

[23] S. Descotes-Genon, L. Girlanda and J. Stern: "Chiral order and fluctuations in multiflavour QCD", Eur. Phys. J. C27 (2003) 115 [hep-ph/0207337]

[24] S. Descotes-Genon, N.H. Fuchs, L. Girlanda and J. Stern: "Resumming QCD vacuum fluctuations in three-flavour Chiral Perturbation Theory", Eur. Phys. J. C34 (2004) 201 [hep-ph/0311120]

Talks and lectures at international conferences

[25] 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, IPPP Durham (UK), April 2003, eConf C0304 052:WG111 (2003); to appear in M. Bataglia et al., The CKM matrix and the Unitarity triangle, CERN Yellow Report (CERN 2003-002-corr)

[26] 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 2nd Workshop on the CKM Unitarity Triangle, IPPP Durham (UK) April 2003, eConf C0304052:WG415 (2003) [hep-ph/0306271]; to appear in M. Bataglia et al., The CKM matrix and the Unitarity triangle, CERN Yellow Report (CERN 2003-002-corr)

[27] T.N. Pham: "Non factorizable effects in $B \to \chi_{c0}K^-$ from charmed meson rescattering", eConf C030614 (2003) 026 [hep-ph/0310129] Talk presented at QCD @ Work 2003, Conversano (Italy), June 2003

[28] B. Moussallam, "Chiral perturbation theory: A basic introduction," [hep-ph/0407246]. Lectures given at 20th General FANTOM Study Week on QCD at Low Energies, Emmen (Netherlands), May 2004.

[29] P. Büttiker, S. Descotes-Genon and B. Moussallam: "πK scattering inputs to ChPT", [hep-ph/0310045]. Talk presented at the 10th QCD international conference, Montpellier (France), July 2003

[30] S. Descotes-Genon: "QCD factorisation in radiative B-decays", Eur. Phys. J. C online (2003), DOI 10.1140/epjcd/s2003-03-122-5. Talk presented at the Int. Europhysics Conf. on High-Energy Physics 2003, Aachen (Germany), July 2003

3.6 UK Durham/Oxford

Participant Number 6 : DUR, UK Durham/Oxford

M. R. Pennington (*Durham*) (50%); *Oxford*: F. E. Close (50%), R. H. Dalitz (25%), J.J. Dudek (100%); *Manchester*: A. Donnachie (40%); *Durham*: P. Ball (10J. Hirn (92

Scientific Staff

Total: 8 researchers ≡ 50 p-m/y

Scientific Highlights

A major interest of the UK node has been in the new hadronic states, both mesons and baryons, that have been discovered in a series of experiments at BaBar, Belle, Fermilab and JLAB. The focus has been on the interpretation of these states and their relation to QCD dynamics. Further studies involve the investigation of effective electroweak theories which have no explicit Higgs, the role of condensates in the QCD vacuum and of diffractive processes in QCD — all topics relevant to present and future collider experiments.

Travel paid by Durham

1. Workshop on e^+e^- collisions in the 1-2 GeV range: Physics and accelerator prospects, Alghero, Sardinia, Italy 10-13th September 2003. M.R. Pennington
2. Collaboration with INFN-Milano, 10-13th November 2003. M.R. Pennington
3. Collaboration meetings at Orsay, December 2003, January, March 2004 J. Hirn
4. Euridice Collaboration Meeting, Vienna, Austria, 11-15th February 2004. J. Hirn and M.R. Pennington.
5. Meeting with KLOE radiative ϕ-decay group, LNF, Frascati, Italy, 6-8th June 2004. M.R. Pennington
6. Collaboration meeting Durham 16-23rd June 2004. L. Edera (Milan, Italy)

Personnel supported by the network

- K. Benhaddou (France) (PhD student) September-November 2003
- J. Hirn (France) (PhD student) October 2003-September 2004.

Relevant Publications

1. F.E. Close and P.R. Page, *The $D_0^*\overline{D}_0$ threshold resonance*, hep-ph/0309253 Phys.Lett. B578:119-123,2004.

2. F.E. Close, *The end of the constituent quark model?*, hep-ph/0311087, Talk given at Hadron 03: 10th International Conference on Hadron Spectroscopy, Aschaffenburg, Germany, Aug-Sept. 2003

3. J.J. Dudek and F.E. Close, *The $J = 3/2$ Θ^* partner to the $\Theta(1540)$ baryon*, hep-ph/0311258 Phys.Lett. B583:278-284,2004.

4. F.E. Close and J.J. Dudek, *Pentaquark symmetries, selection rules and another potentially narrow state*, hep-ph/0401192 Phys.Lett. B586:75-82, 2004.

5. F.E. Close and Qiang Zhao, *A note on glueball hunting in $e^+e^- \to J/\psi \to \phi f_0$*, hep-ph/0402090 Phys.Lett. B586:332-336,2004.

6. F.E. Close and Qiang Zhao, *Photoproduction of Θ^+ and other pentaquark states*, hep-ph/0403159 Phys.Lett. B590:176-184,2004.

7. Qiang Zhao and F.E. Close, *On the experimental status of Θ^+ and Σ_5^+ pentaquarks*, hep-ph/0404075.

8. T. Barnes, F.E. Close, J.J. Dudek, S. Godfrey and E.S. Swanson, *Options for the SELEX state $D_{sJ}^+(2632)$*, hep-ph/0407120.

9. 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).

10. M.R. Pennington, *Light-by-light scattering at a low energy e^+e^- collider: what to do while waiting for that rare kaon decay event*, hep-ph/0311299 Proceedings of the Workshop on e^+e^- collisions in the 1-2 GeV range: Physics and accelerator prospects, Alghero, Sept 2003 (eConf C0309101).

11. M.R. Pennington, *Building bridges in QCD down under* Proceedings of Workshop on QCD Down Under, Adelaide, March 2004 (to be published).

12. M.R. Pennington, *Swimming with quarks*, Lectures at the XI Mexican School in Particles and Fields, August 2004 (to be published).

13. J. Hirn and J. Stern, *The role of spurions in Higgs-less electroweak effective theories*, hep-ph/0401032, Eur.Phys.J. C34:447-475,2004.

14. J. Hirn and J. Stern, *Anomaly matching and Higgs-less effective theories*, hep-ph/0403017.

15. A. Donnachie and P.V. Landshoff, *Soft diffraction dissociation*, hep-ph/0402081, Phys. Lett B595: 393-399, 2004

16. P. Ball and M. Boglione, *$SU(3)$ breaking in K and K^* distribution amplitudes*, hep-ph/0307337, Phys. Rev. D68: 094006, 2003.

17. P. Ball, *The theory of CP-violation: in as much of a nutshell as will fit on 8 pages*, hep-ph/0406326 Proceedings of Workshop on Physics at Meson Factories, Frascati, June 2004 (to be published).

3.7 Lund University

Participant Number 7 : ULUND Lund University

SCIENTIFIC STAFF

Lund: Johan Bijnens (10 m/y 83%), P. Dhonte, N. Danielsson, F. Borg (Ph.D. Students 10 m/y 83%), T. Lähde (Postdoc EU 11 m total 100%) Post-doc (non EU, 1 m total 100%) Total: 52 m/y
Oslo: Jan Eeg (10 m/y 83%), Total: 10 m/y
Total: 7 researchers ≡ 62 p-m/y

Scientific Highlights

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

- The full two-loop calculation in 3 flavour ChPT of $\pi\pi$ and πK [7,8] scattering and the first two-loop calculation in partially quenched ChPT [11].
- The local part of isospin breaking in $K \to 3\pi$ decays [9].
- Colour suppressed B decays with vector mesons in the final state [18].

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 $\pi\pi$ and πK scattering where in both cases the full two-loop calculation has been performed [7,8]. This allowed also to study the quality of the progression of Chiral perturbation Theory from two to three flavours as well as a deeper study of the large N_c suppressed effects in the low energy constants. The best values for the latter were consistent with the expected violations of the large N_c estimates.

In $K \to 3\pi$ decays we finished and published the calculation of the quark mass and local electromagnetic isospin breaking effects [9]. These effects were found to be fairly small and could not solve the discrepancy with experiment existing in the isospin conserving limit. The calculation of the nonlocal photonic effects, the radiative corrections, is now in progress.

A major development has been the work on two-loop ChPT calculations for partially quenched lattice gauge theory [11]. We have finished the first nontrivial calculation here and many more are in progress.

II) Theoretical and Phenomenological Studies

The work on the CKM matrix element V_{us} has been presented at several meetings as well as in many private discussions [5,13].

Work on D-decays [14] and B-decays[15-18] has been presented at several meetings. The work on colour suppressed decays of the type $\bar{B} \to D\bar{D}$ [15] is extended [18] to vector mesons in the final state.

The CP violation studies have continued by developing further the ladder resummation model and its application to nonleptonic matrix elements [2].

III) Future experiments and identification of relevant hadronic quantities
No progress this period.

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, JHEP 10(2003)061

2. **Hadronic Matrix Elements for Kaons,** J. Bijnens, E. Gamiz and J. Prades hep-ph/0309216, to be published in Nucl. Phys. B proc. suppl. **Lund-Granada**

3. **Summary of the Goldstone Boson Working group,** J. Bijnens and A. Farilla, -, -, Presented at CHIRAL DYNAMICS 2003 Theory and Experiment Bonn/Germany, September 8-13, 2003, published in the proceedings.

4. $K \to 3\pi$ **in Chiral Perturbation Theory,** J. Bijnens, F. Borg and P. Dhonte, -, -, Presented at CHIRAL DYNAMICS 2003 Theory and Experiment Bonn/Germany, September 8-13, 2003, published in the proceedings.

5. $K_{\ell 3}$ **at two loops in ChPT,** J. Bijnens and P. Talavera, -, -, Presented at CHIRAL DYNAMICS 2003 Theory and Experiment Bonn/Germany, September 8-13, 2003, **Lund-Barcelona**

6. **Scalar Form Factors to** $\mathcal{O}(p^6)$ **in** $SU(3)$ **Chiral Perturbation Theory,** J. Bijnens and P. Dhonte, -, -, Presented at CHIRAL DYNAMICS 2003 Theory and Experiment Bonn/Germany, September 8-13, 2003, published in the proceedings.

7. $\pi\pi$ **Scattering in Three Flavour ChPT,** J. Bijnens, P. Dhonte and P. Talavera, LU TP 04-02, hep-ph/0401039, JHEP 0401(2004)050, **Lund-Barcelona**

8. πK **Scattering in Three Flavour ChPT,** J. Bijnens, P. Dhonte and P. Talavera, LU TP 04-19, hep-ph/0404150, JHEP 0405(2004)036, **Lund-Barcelona**

9. **Isospin Breaking in** $K \to 3\pi$ **Decays I: Strong Isospin Breaking,** J. Bijnens and F. Borg, LU TP 04-20, hep-ph/0405025, to be published in Nucl. Phys. B.

10. **Estimating the Electromagnetic Chiral Lagrangian Coefficients,** A. Pinzke, LU TP 04-22, hep-ph/0406107, Master thesis.

11. **The Pseudoscalar Meson Mass to Two Loops in Three-Flavor Partially Quenched** χ**PT,** J. Bijnens, N. Danielsson and T.A. Lähde, LU TP 04-26, hep-lat/0406017.

12. **Isospin Breaking in $K \to 3\pi$ decays,** F. Borg, poster talk presented at DAΦNE 04.

13. **Chiral Meson Physics at Two Loops,** J. Bijnens, talk presented at the 19th European Few Body Meeting in Groninen, the Netherlands, 22-27 august 2004.

14. **The beta-term for $D^* \to D\gamma$ within a heavy light chiral quark model,** A. Hiorth and J.O. Eeg, *Eur.Phys.J.C. direct* (2004) DOI 10.1140/epjcd/s2004-01-003-1

15. **On the colour suppressed decay modes to $\bar{B}^0_d \to D^+_s D^-_s$ and $\bar{B}^0_s \to D^+ D^-$,** J.O. Eeg, S. Fajfer, A. Hiorth, *Phys. Lett.* **B 570** (2003) 46-52

16. **B decays and $B\bar{B}$ mixing within a heavy light chiral quark model,** J.O. Eeg,. WQCD-2003-024, Oct 2003. . Talk given at QCD @ Work 2003: 2nd International Workshop on Quantum Chromodynamics: Theory and Experiment, Conversano, Italy, 14-18 Jun 2003. Published in *eConf* **C 030614** (2003) 024; Also in *Conversano 2003, QCD at work 2003* 171-178. (hep-ph/0310179)

17. **On the singlet penguin in $B \to K\eta'$ decay,** J.O. Eeg, K. Kumericki, I. Picek, Proceedings of 9th Adriatic Meeting, Dubrovnik, Croatia, 4-14 Sep 2003, hep-ph/0407279.

18. **Non-factorizable contributions to $\bar{B}^0_d \to D^{(*)}_s \bar{D}^{(*)}_s$,** J.O. Eeg, S. Fajfer, A. Hiorth, A. Prapotnik, hep-ph/0408298. Based on talk given by J.O. Eeg at BEACH2004, 6th international conference on Hyperons, Charm and Beauty Hadrons, Illinois Institute of Technology, june 27.-july 3., Chicago, 2004.

Networking

In the EURIDICE meeting in Vienna in february 2004 J. Bijnens, P. Dhonte, J.O. Eeg, T.A. Lähde and J. Bijnens participated. In addition the ongoing Lund-Granada exchange has gone with visits of J. Prades to Lund in september 2003 and J. Bijnens to Granada in December 2003. N. Danielsson (PhD student in Lund), A. McDonald Sørensen and K. Eide (master students in Oslo) attended the spring school in Frascati in may 2004. F. Borg attended the DAΦNE04 conference in June 2004. In addition many presentations were given at other scientific meetings.

Young Researchers and PhD Students

Timo Lähde, Finnish, has started on 1oct 2003 and is expected to continue until the end of sept 2005. One PhD student, P. Dhonte obtained his PhD from Lund in June 2004.

3.8 University of Helsinki

Participant Number 8 : UHELS University of Helsinki

Nils A. Törnqvist (60%) , A. Green (75%), D.-O. Riska (16%), M. Sainio (16%), B. Julia-Diaz (100% , financed by Euridice for 10 months), J. Koponen (90%), T. Lähde (10 %), P. Piirola (90%)

SCIENTIFIC STAFF

Total: 8 researchers ≡ 55 p-m/y

Scientific Highlights

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

A systematic study of the electromagnetic and axial vector current matrix elements of the baryons and the baryon resonances was carried out in instant, point and front form kinematics with the constituent quark model. By considering the magentic moments and the charge radii of hyperons of all flavors a phenomenological preference for instant and front form kinematics was found. A new choice of kinematics, which allows extension of front form kinematics to the timelike region was found. Form factors of baryons and of the light flavor mesons were calculated up to 10 GeV^2 in all three forms of kinematics. The pion decay widths of the lowest nucleon and Δ resonances were calculated. In the same line the electromagnetic form factors of the pion and the rho where investigated using the different forms of kinematics. The non-appropriateness of point form to study light systems, as the pion, was confirmed. It was also found that instant and front form provide a similar picture of the rho form factors.

The existence of bound deuteron-like states of the recently discovered double-charm hyperons and nucleons were studied by extrapolation of a set of realistic nucleon-nucleon interactions to the heavy flavor hyperons. The different interaction models led to widely different calculated binding energies, yet allowing the overall conclusion that deuteron-like bound states of double-charm hyperons are likely.

Research Objectives

N.T. will continue his work in the light meson team of the Particle Data Group, which now starts preparing for the next edition of the Review of Particle Physics planned for 2006. He will also continue his work on the nature of the lightest scalar mesons, as well as on the recently observed new 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.

Study the uncertainties in the eta-Nucleon interaction is continuing in colaboration with Warsaw.

The extraction of charge and matter radial distributions for P- D- and F-wave heavy-light mesons using lattice QCD and the interpretation of these results in terms of wave equations.

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.

Networking

M. Sainio visited U. Bern 3.-5.11. and 28.-29.11.2003.
S. Wycech (Warsaw) visited U. Helsinki 30.10.-29.11.2003.

Conferences

M. Sainio and B. Julia-Diaz participated in the 3rd Euridice collaboration meeting in Vienna 12.-14.2.2004.

Training

Dr. Bruno Julia-Diaz, Spanish, age 27, joined the group starting from June 2nd, 2003 with an expected stay of 16.5 months whereof 13 months would be covered by the EU grant. (The remaining funds in the "Young researcher" category were tranfered to "Networking" category with the permission of the Commission. This did not constitute a detriment to the young researcher, and was not causing a substantial reduction of the personnel costs to get anywhere close to the 60 % limit.)

Publications of the Node

1. A.M. Green and S. Wycech, *η-π mixing close to the η-Helium threshold*, Phys. Rev. **C68**, 061601 (2004) [nucl-th/0308057].

2. C. Amsler and N. A. Törnqvist, *Mesons beyond the naive quark model*, Physics Reports **389**, 61 (2004).

3. B. Julia-Diaz, A. Valcarce, F. Fernandez, *A microscopic $NN \to NN^*(1440)$ potential*, Eur. Phys. J. **A19**, s01, 99 (2004) [nucl-th/0310072]

4. B. Julia-Diaz and D.O. Riska, *Baryon form factors of relativistic constituent-quark models*, Phys. Rev. **C69**, 035212 (2004) [hep-ph/0312169].

5. B. Julia-Diaz and D.O. Riska, *Baryon magnetic moments in relativistic quark models*, Nucl. Phys. **A739**, 69 (2004) [hep-ph/0401096].

6. B. Julia-Diaz and D.O. Riska, *Nuclei of Double-Charm Hyperons*, [nucl-th/0405061].

7. B. Julia-Diaz and D.O. Riska, *Axial Transition Form Factors and Pion Decay of Baryon Resonances*, [nucl-th/0406015].

8. Jun He, B. Julia-Diaz and Yu-bing Dong, *Electromagnetic form factors of pion and rho in the three forms of relativistic kinematics*, [hep-ph/0407043].

9. F. Frömel, B. Julia-Diaz and D.O. Riska, *Bound states of heavy flavor hyperons*, in preparation.

10. Nils A. Törnqvist, *Isospin breaking of the narrow charmonium state at Belle at 3872 MeV as a deuson*, Phys. Lett. **B590**, 209 (2004) [hep-ph/0402237].

11. PDG including N.A. Törnqvist, *Review of particle physics*, Phys. Lett. **B592**, 1 (2004).

3.9 DESY Zeuthen

Participant Number 9 : DESY Zeuthen

Friedrich Jegerlehner, K. Jansen, Kei-ichi Nagai (each 6 m/year), M. Awramik, O. Tarasov, B. Leder, H. B. Meyer (4 m/year), R. Sommer (3 m/year) **DESY** Total: 37 p-m/y Scientific Staff
W. Kluge, A. Denig, S. Müller, B. Valeriani, C. Bruch, D. Leone (each 12 m/year), T. Selz (6m/year), A. Khodjamirian (4m/year), J. Kühn, K. Chetyrkin (each 3 m/year) **Univ. Karlsruhe** Total: 88 p-m/y

Scientific Highlights

The DESY/Karlsruhe team made substantial progress in the investigation of low energy hadronic cross sections both experimentally (KLOE) and theoretically (PHOKHARA). The new KLOE result for the cross section $\sigma(e^+e^- \to \pi^+\pi^-)$ plays an important role in improving the calculation of hadronic effects in electroweak precision observables like a_μ and $\alpha_{\rm em}(M_Z)$. A pioneering calculation of the full two-loop fermionic electroweak corrections to the effective leptonic weak mixing angle in the standard model has been completed.

Research Objectives

The research objectives of the Zeuthen/Karlsruhe team are still relevant and achievable. We still consider it to be an important challenging 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, now for both μ^- (new) and μ^+, as well as the ongoing precision measurements of low energy hadronic cross-sections at KLOE/Dafne (Frascati), CLEO-C (Cornell), 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 energy hadron phenomenology. Substantial progress in precision determination of fundamental parameters of the SM/QCD has been achieved and more progress is expected soon.

Networking

Karlsruhe/Katowice (subnode of DESY Zeuthen and team from Warsaw node) /Valencia activities [1]–[10]:
The emphasis of the theoretical research of the Karlsruhe subnode was again on studies for the radiative return, in particular the development of the Monte Carlo program PHOKHARA. This work was performed in close collaboration with the polish subnode Katowice and the Spanish node Valencia. The project was motivated by the ongoing experimental analysis and the publications of the KLOE Collaboration on the pion form factor and by related studies at B meson factories.

On the one hand additional hadronic modes were implemented in the program, on the other hand much effort was spent to push to precision to the permille level through the inclusion of more elaborated radiative corrections.

Specifically, in view of the larger energies accessible at B-meson factories, the production of nucleon-antinucleon final states and the measurement of the electric and the magnetic form factors is possible through the radiative return. The analysis was shown to be particularly simple in the nucleon-antinucleon rest frame, with the z-axis chosen in the direction of the real photon. The corresponding generator was constructed and tested, and the feasibility of the analysis under realistic conditions was demonstrated [1].

For pion as well as muon pair production radiative corrections were implemented, which originate from double photon emission, with one photon radiated from the initial and the other from the final state. It was demonstrated that the effect modifies some distributions to a sizable level and may influence the extraction of the pion form factor. However, using suitable observables and cuts, the anticipated experimental precision can be recovered [2, 3].

The results were presented at a number of workshops and international conferences [4]–[10].

DESY Zeuthen/Katowice (participant from Warsaw) /Durham activities [11]–[20]:
with the goal to improve the precision of the basic standard model parameters a number of elaborate calculations at the two-loop level have been performed. The presently most accurate prediction for the W-boson mass in the Standard Model (SM) was obtained by combining the complete two-loop result with the known higher-order QCD and electroweak corrections [11]. The numerical impact of the different contributions was analyzed in detail. Their effect on the prediction of M_W is estimated to be about 4 MeV for M_H ¡ 300 GeV. Furthermore, a complete calculation of the contributions from closed fermion loops at the two-loop level of the electroweak interactions to the effective leptonic weak mixing angle, $\sin^2\theta_{\rm eff}^{\rm lept}$, has been performed [12, 13]. This quantity provides the most stringent bound on the mass M_H of the as yet undiscovered Higgs boson. The size of the corrections with respect to known partial results translates into a shift of the predicted central value of M_H by +19 GeV, to be compared with the shift induced by a recent change in the measured top quark mass which amounts to +36 GeV.

Another activity concerned the calculation of the $O(\alpha\alpha_s)$ contributions to the relationship between the $\overline{\rm MS}$-mass and the pole of the top quark propagator [15, 16]. The relationship between the broken and the unbroken phase of the SM and its consequences for the renormalization group evolution of electroweak parameters has been investigated and clarified.

Additional effort went into reducing theoretical uncertainties in $(g-2)_\mu$ of the muon and the effective fine structure constant $\alpha_{\rm em}(M_Z)$ [17]–[19]. The new measurement of $\sigma(e^+e^- \to \text{hadrons})$ from KLOE (Frascati 2004) is in rather good agreement with the corresponding CMD-2 (Novosibirsk 2003) result, however, confirms a large discrepancy between the e^+e^--data and the τ-data (after applying the known isospin corrections). As proposed in [17], the large deviation may be explained largely in terms of additional isospin breaking effects due to the differences between masses and widths of the charged and neutral ρ mesons. Since the hadronic contribution to the muon anomalous magnetic moment can be calculated directly in terms of the e^+e^- - data the corresponding evaluation is more reliable. The τ - data cannot be used to improve the evaluation of the vacuum polarization effects without further input from theory.

DESY Zeuthen/Berne activities [21]:
concentrated on matching chiral perturbation theory in the so-called epsilon regime, where the Compton wavelength of the pion is much larger than the box size, with lattice results. This regime allows by finite size scaling techniques to extract low energy constants of the

chiral Lagrangian. Problems with different formulations of dynamical chiral fermions have been analyzed and various difficulties have been pointed out [22]–[24].
Zeuthen/Marseille activities [25]–[27]:
investigated the validity of the square rooting procedure of the staggered determinant in the context of the Schwinger model. Some evidence is found that at fixed physical quark mass the square root of the staggered fermion determinant becomes proportional to the overlap fermion determinant in the continuum limit. The analysis supports square-rooting the staggered determinant to obtain dynamical ensembles with $N_f = 2$.
DESY Zeuthen other activities [28, 29]: a strategy has been developed for a non-perturbative computation of the b-quark mass to leading order in $1/m$ in the Heavy Quark Effective Theory (HQET). The approach avoids the perturbative subtraction of power law divergencies, and the continuum limit may be taken. First numerical results in the quenched approximation demonstrate the potential of the method with a preliminary result m_b(4GeV)=4.56(2)(7) GeV. In principle, the idea may also be applied to the matching of composite operators or the computation of $1/m$ corrections in HQET.
Karlsruhe/Frascati/Pisa activities [30]–[51]:
In the last years the *Karlsruhe* group participated in the general activities of the *KLOE* collaboration of data taking, data reconstruction and data analysis. We concentrated our activity onto the measurement of the hadronic cross section. Usually the energy dependence of the cross section is measured by changing the energy of the accelerator. DAΦNE, however, will be operated at the fixed energy of the $\phi-$resonance for the years to come. Hence, J. H. Kühn and collaborators, and subsequently our group, proposed to use events with the emission of real photons in the initial state (Initial State Radiation *ISR*) in order to determine the energy dependence of the dominant reaction $e^+e^- \to \gamma\,\gamma^\star \to \gamma\,\pi^+\,\pi^-$. *ISR* reduces the center-of -mass energy $s = Q^2 = m_\phi^2 - 2E_\gamma\, m_\phi$ of the annihilating electrons and positrons and consequently the energy of the final state from the $\phi(1020)-$resonance down to the 2−pion threshold. Both methods to measure the energy dependence of the cross section (*ISR* and energy scan) are complementary due to different systematic errors. In a first step the cross section of the reaction $\sigma(e^+e^- \to \pi^+\pi^-\gamma)$ has been measured between 0.6 and 1.0 GeV with a statistical error of less than 0.2 % and a systematic error of 1.3 %. The analysis depends sensitively on Monte Carlo generators for radiative corrections as well in the initial as in the final state developed by the theory group of J. H. Kühn and H. Czyż in recent years. In order to determine the cross section for the reaction $e^+e^- \to \pi^+\pi^-$ the data have been divided by the radiator function calculated with the code *PHOKHARA* (with higher order *ISR* and *FSR* for point like pions), and the pion angle interval has been extended to cover the full angular region from 0^o to 180^o using Monte Carlo calculations for this acceptance correction. The photon angular interval remains restricted to $\theta_\gamma < 15^o$ and $\theta_\gamma > 165^o$.
The hadronic correction to the vacuum polarization for a_μ obtained in the interval $0.37 < Q^2 < 0.93\,GeV^2$ is $a_\mu^{\pi\pi} = (375.6 \pm 0.8_{stat} \pm 4.8_{syst.+theor.}) \cdot 10^{-10}$. To arrive at this result the vacuum polarization for the virtual photon ($\gamma^\star$) has been taken out to obtain the bare cross section and a correction for *FSR* of the order of $(1 \pm 0.15)\%$ has been applied. The experimental result is in good agreement with the value of the group CMD-2 of Novosibirsk and confirms the present discrepancy of the hadronic correction using data of electron-positron annihilation on the one hand and τ-decay data on the other. At present our total systematic error of 1.3 % includes an experimental systematic error of 0.9 % and a theoretical systematic error of 0.9 % taken in quadrature. Visiting scientists from or at other EURIDICE

nodes:

- F. Jegerlehner, Ustron/Katowice Workshop, Ustron/Poland, Sep 15-21, 2003
- M. Kalmykov, Ustron/Katowice Workshop, Ustron/Poland, Sep 15-21, 2003
- F. Jegerlehner, Pisa EURIDICE Workshop on $\sigma_{\rm hadronic}$, Pisa/Italy, Oct 8-10, 2003
- J. Kühn, Pisa EURIDICE Workshop on $\sigma_{\rm hadronic}$, Pisa/Italy, Oct 8-10, 2003
- W. Kluge, Pisa EURIDICE Workshop on $\sigma_{\rm hadronic}$, Pisa/Italy, Oct 8-10, 2003
- S. Dürr, visiting CNRS Marseille, Nov 28-31, 2003
- T. Westwanski, Univ. of Silesia, Katowice [Warsawa node] visiting DESY Zeuthen, Dec 9-20, 2003
- S. Dürr, visiting Berne Univ., Jan 16-17, 2004
- F. Jegerlehner, EURIDICE Collab. Meeting, Vienna, Feb 11-15, 2004
- M. Czakon, EURIDICE Collab. Meeting, Vienna, Feb 11-15, 2004
- W. Kluge, EURIDICE Collab. Meeting, Vienna, Feb 11-15, 2004
- F. Jegerlehner, DESY Zeuthen visiting Frascati, Mar 1-14, 2004 (TARI 2004)

  R. Sommer, visiting Berne Univ.[discussions on chiral perturbation theory and LGT, G. Colangelo and R. Sommer, June 21, Bern], 21st of June 2004
- K. Kołodziej, Univ. of Silesia, Katowice [Warsawa node] visiting DESY Zeuthen, 16 Feb - 5 Mar, 22 Mar - 8 Apr, 5 Jul - 17 Jul 2004
- H. Leutwyler, Univ. of Berne, visiting DESY Zeuthen, Mai 1-31, 2004 (Preisträger der Humboldt Stiftung)
- A. Denig, Univ. of Karlsruhe, visiting DESY Zeuthen, Jun 14-16, 2004
- H. Leutwyler, Univ. of Berne, visiting DESY Zeuthen, Jul 14-16, 2004
- W. Kluge, Univ. of Karlsruhe, visiting DESY Zeuthen, Jul 14-16, 2004
- J. H. Kühn, Univ. of Karlsruhe, visiting DESY Zeuthen, Jul 14-16, 2004
- H. Czyż, Univ. of Silesia, Katowice [Warsawa node] visiting Univ. of Karlsruhe, 5 month 2004
- A. Grzelińska, Univ. of Silesia, Katowice [Warsawa node] visiting Univ. of Karlsruhe, 3 month 2004
- E. Nowak, Univ. of Silesia, Katowice [Warsawa node] visiting Univ. of Karlsruhe, 2 month 2004
- G. Rodrigo, Univ. of Valencia, visiting Univ. of Karlsruhe, 2 month 2004

- W. Kluge, Univ. of Karlsruhe, visiting LNF Frascati, 2 month 2004
- A. Denig, Univ. of Karlsruhe, visiting LNF Frascati, 1 month 2004
- D. Leone, Univ. of Karlsruhe, visiting LNF Frascati, 2 month 2004
- S. Müller, Univ. of Karlsruhe, visiting LNF Frascati, 2 month 2004
- B. Valeriani, Univ. of Karlsruhe, visiting LNF Frascati, 1 month 2004

Talks at DESY Zeuthen by visitors from other EURIDICE nodes:

- N. Glover (Durham Univ.),
  Progress in $N(N)LO$ QCD
  16-OCT-03 DESY-HU Theory-Seminar
- M. Misiak (Univ. Warschau),
  $NNLO$ QCD calculations of rare B decays
  11-MAR-04 15:00 DESY-HU Theory-Seminar
- K. Kołodziej (Univ. of Silesia),
  Towards High Precision Theoretical Predictions for a Linear Collider
  6-MAY-04 DESY-HU Theory Seminar
- A. Signer (Durham Univ.),
  Infrared-Finite Amplitudes
  27-MAY-04 DESY-HU Theory Seminar
- A. Denig (Univ. of Karlsruhe),
  Recent Results from KLOE at the Electron-Positron Collider DAΦNE
  7-JUL-04, DESY Zeuthen Physics Seminar
- L. Trentadue (INFN, Univ. of Parma),
  The Running of the $\alpha_{\rm QED}$ in small angle Bhabha scattering
  9-JUN-04, DESY Zeuthen Physics Seminar
- H. Leutwyler (Univ. Bern)
  Qualitative Aspects of the Standard Model
  15-JUL-04, DESY Zeuthen Kolloquium

Talks by F. Jegerlehner:

- SIGHAD03, Pisa (Italy), Oct 8-10, 2003
  Workshop on hadronic cross sections
  The Role of Hadronic Effects in Precision Tests of the Standard Model

- ACAT03, Tsukuba (Japan), Dec 1-5, 2003
  IX Intern. Workshop on Advanced Computing ...
  Steps towards full two-loop calculations for 2 fermion to 2 fermion processes

- LoopFest III, Santa Barbara (USA), Apr 1-3, 2004
  Radiative Corrections for the Linear Collider: Multi-loops and Multi-legs
  Status of the muon g-2 and the theoretical uncertainty of the hadronic contributions

Talks by M. Czakon:

- ECFA/DESY Workshop Montpellier (France), Nov 13-16, 2003
  Two-loop Fermionic Contributions to the Effective Weak Mixing Angle

- EURIDICE Collab. Meeting Vienna (Austria), Feb 11-15, 2004
  Two-loop Fermionic Contribution to the Effective Weak Mixing Angle

- Loops and Legs 2004, Zinnowitz (Germany), 25-30 May 2004
  7^{th} DESY Workshop on Elementary Particle Theory
  The effective leptonic weak mixing angle to two loop order in the electro-weak interactions

Talks by M. Awramik:

- LCWS 04, Paris (France), Apr 19-23, 2004
  International Conference on Linear Colliders
  Two-loop corrections to the effective mixing angle $\sin^2\theta_{\text{eff}}$

- LoopFest III, Santa Barbara (USA), Apr 1-3, 2004
  Radiative Corrections for the Linear Collider: Multi-loops and Multi-legs
  Next-to-next-to-leading order corrections to the effective weak mixing angle

Talks by J. H. Kühn:

- SIGHAD03, Pisa (Italy), Oct 8-10, 2003
  Workshop on hadronic cross sections
  Status and prospects of MC tools for ISR

- LoopFest III, Santa Barbara (USA), Apr 1-3, 2004
  Radiative Corrections for the Linear Collider: Multi-loops and Multi-legs
  New results on multi-loop calculations

Talks by W. Kluge:

- Loops and Legs 2004, Zinnowitz (Germany), 25-30 May 2004
  7^{th} DESY Workshop on Elementary Particle Theory
  *Physics with*DAΦNE
- HS 2004, Smolenice (Slovakia), Aug 30 - Sep 3, 2004
  Int. Conf. on Hadron Structure 2004
  The reaction $\sigma(e^+e^- \to \pi^+\pi^-)$ and its relation to the anomalous magnetic moment of the muon

Talks by B. Valeriani:

- SIGHAD03, Pisa (Italy), Oct 8-10, 2003
  Workshop on hadronic cross sections
  The hadronic cross section measurement at KLOE

Talks by D. Leone:

- EURIDICE Collab. Meeting Vienna (Austria), Feb 11-15, 2004
  Measurement of the hadronic cross section with the KLOE detector

Talks by A. Denig:

- SIGHAD03, Pisa (Italy), Oct 8-10, 2003
  Workshop on hadronic cross sections
  Future plans for Dafne
- MENU 2004, Beijing (China), Aug 29 - Sep 4, 2004
  10^{th} Int. Symposium on Meson-Nucleon Physics and the Structure of the Nucleon
  Recent results from KLOE at the e^+e^- collider DAΦNE

Talks by S. E. Müller:

- MENU 2004, Beijing (China), Aug 29 - Sep 4, 2004
  10^{th} Int. Symposium on Meson-Nucleon Physics and the Structure of the Nucleon
  Measurement of the hadronic cross section $\sigma(e^+e^- \to \pi^+\pi^-\gamma)$ with KLOE

Talks by M. Kalmykov:

- Ustron 03, Ustron (Poland), Sep 15-21, 2003
  27^{th} Int. Conf. of Theoretical Physics: Recent Developments in Physics of Fundamental Interactions
  The $O(\alpha\alpha(s))$ correction to the pole mass of the t-quark within the standard model

- Loops and Legs 2004, Zinnowitz (Germany), May 25-30, 2004
  7^{th} DESY Workshop on Elementary Particle Theory
  Series and ϵ-expansion of the hypergeometric functions

Work Plan

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

Postdoctorands

Dr. Michal Czakon, started 1st of October 2003 at DESY Zeuthen.

References

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Plenary talk at Workshop on Physics at Meson Factories (DAFNE 2004), Rome, Frascati, Italy, 7-11 Jun 2004.
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Invited talk at Workshop on e+ e- in the 1-GeV to 2-GeV Range: Physics and Accelerator Prospects - ICFA Mini-workshop - Working Group on High Luminosity e+ e- Colliders, Alghero, Sardinia, Italy, 10-13 Sep 2003.
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The KLOE Collaboration
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The KLOE Collaboration
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The KLOE Collaboration
Phys. Lett. **B 597** (2004) 139

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The KLOE Collaboration
Phys. Lett. **B** , submitted for publication

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S. E. Müller for the KLOE Collaboration
International Conference on the Structure and Interactions of the Photon including the 15^{th} International Workshop on Photon-Photon Collisions, LNF, April 7 - 11, 2003
Nucl. Phys. **B 126** (Proc. Suppl.) (2004) 335

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B. Valeriani-Kaminski for the KLOE Collaboration
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A. Denig
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Nucl. Phys. **B 131** (Proc. Suppl.)(2004) 88

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D. Leone for the KLOE collaboration
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A. Denig
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[39] Measurement of $\sigma(e^+e^- \to \pi^+\pi^-)$ with the KLOE detector
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Verhandlungen der Deutschen Physikalischen Gesellschaft, Spring Meeting Cologne 2004, March 8-12, 2004, HK 3.2

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W. Kluge
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S. E. Müller
4th KLOE Physics Workshop, May 31 - June 3, 2004, Karlsruhe

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D. Leone
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[43] Final KLOE result on hadronic cross section $\sigma(e^+e^- \to \pi^+\pi^-)$
A. Denig
4th KLOE Physics Workshop, May 31 - June 3, 2004, Karlsruhe

[44] Background estimate for the measurement $\sigma(e^+e^- \to \pi^+\pi^-\gamma)$
F. Nguyen
4th KLOE Physics Workshop, May 31 - June 3, 2004, Karlsruhe

[45] Measurement of the $\sigma(e^+e^- \to \pi^+\pi^-\gamma)$ cross section below $1GeV$ with the KLOE detector
F. Nguyen for the KLOE collaboration
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A. Denig
Institutsseminar, Institut für Kern- und Teilchenphysik, TU Dresden, 17. 6. 2004

[47] Recent results from KLOE at the e^+e^- collider DAΦNE
A. Denig
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[48] Measurement of the hadronic cross section $\sigma(e^+e^- \to \pi^+\pi^-\gamma)$ with KLOE
D. Leone for the KLOE collaboration
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A. Denig for the KLOE collaboration
10^{th} Int. Symposium on Meson-Nucleon Physics and the Structure of the Nucleon, August 29 - Sept. 4, 2004, MENU 2004, Beijing, to be published in the Proc.

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S. E. Müller for the KLOE collaboration
10^{th} Int. Symposium on Meson-Nucleon Physics and the Structure of the Nucleon, August 29 - Sept. 4, 2004, MENU 2004, Beijing, to be published in the Proc.

[51] The reaction $\sigma(e^+e^- \to \pi^+\pi^-)$ and its relation to the anomalous magnetic moment of the muon
W. Kluge for the KLOE collaboration
Int. Conf. on Hadron Structure 2004, HS 2004, 30. Aug.- 3. Sept., Smolenice (Slovakia)

Expenditures born by the Contract

Traveling			Costs
Name	Place	Date	EURO
Czakon	Montpellier/F	13./16. Nov 2003	851.95
Czakon	Vienna/A	11./15. Feb 2004	573.28
Czakon	Aachen/D	25./27. Feb 2004	481.60
Czakon	Zinnowitz/D	25./30. May 2004	746.20
Kalmykov	Ustron/Katowice/PL	15./21. Sep 2003	809.26
Jegerlehner	Vienna/A	11./15. Feb 2004	605.89

Date	Topic	Input	Output
		EURO	EURO
31.08.2003	Saldo per 1. Sep. 03	36,226.81	
2003/04	Dr. Czakon 11 Month		43,186.00
2004	Transfer to subnode Karlsruhe		5,000.00
03/04	travelings		4,068.18
	sum		52,254.18
	overhead 14% of 52,254.18		7,315.59
	sum	36,226.81	59,569.77
31.08.2004	Saldo per 1. Sep. 04	-23,342.96	

Table 6: Assigned funds and total spent so far, during the first two 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	43,186.00	5,724.49	10,250.00	8,282.47	147,000.00	67,442.96
Total						

3.10 University of Bern

Participant Number 10 : UNIBE University of Bern

Scientific Staff

BERN: **Jürg Gasser**(4m);, G. Colangelo (6m), Ch. Greub (6m), B. Kubis (12m); K. Bieri (11m), M. Schmid (12m), J. Schweizer (10m), P. Zemp (12m) (Ph.D. Students)

ZÜRICH: D. Wyler (4m); E. Lunghi (12m), T. Hurth (12m), A. Nyffeler (3m), W. Porod (4m); S. Schilling (12m), T. Huber (12m) (Ph.D. students)

Total: 15 researchers, 132 p-m/y

Scientific highlights

- We have finalized the evaluation of the spectra and decay widths of $\pi^{\pm}K^{\mp}$ and $\pi^{+}\pi^{-}$ atoms. [1]
- ChPT allows one to perform extrapolation to large volumes and small quark masses in lattice calculations through analytic methods. The group Bern-Zeuthen has taken up this issue and analyzed the behaviour of the pion mass in a finite volume [2].
- We have investigated the rare process $B \to X_d l^+ l^-$ at next-to-next-to-leading logarithmic order for the branching ratio, the CP-asymmetry and the forward-backward asymmetry [3].

[1] J. Schweizer, *Decay widths and energy shifts of $\pi\pi$ and πK atoms*, Phys. Lett. B **587** (2004) 33 [arXiv:hep-ph/0401048].

Project objective: ChPT; Milestones: CHPT-III; Teams involved: Bern

[2] G. Colangelo and S. Durr, *The pion mass in finite volume*, Eur. Phys. J. C **33**, 543 (2004) [arXiv:hep-lat/0311023].

Project objective: ChPT; Milestones: CHPT-II; Teams involved: Bern and DESY-Zeuthen

[3] H. M. Asatrian, K. Bieri, C. Greub and M. Walker, *Virtual- and bremsstrahlung corrections to b → d l+ l- in the standard model*, Phys. Rev. D **69**, 074007 (2004) [arXiv:hep-ph/0312063].

Project objective: Heavy flavour decays; Milestones: Heavy flavors; 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 in the report period is given in the following summaries.

- *Theoretical development of effective field theories*

1. We have further developed effective theories that allow one to perform extrapolations of lattice calculations to large volumes and small quark masses [1,2].

   [1] G. Colangelo and S. Durr, *The pion mass in finite volume*, Eur. Phys. J. C **33**, 543 (2004) [arXiv:hep-lat/0311023].

   [2] G. Colangelo and C. Haefeli, *An asymptotic formula for the pion decay constant in a large volume*, Phys. Lett. B **590**, 258 (2004) [arXiv:hep-lat/0403025].

- *Theoretical and phenomenological studies*

1. We have revisited [1] the scalar form factor in the framework of the Omnes-Muskhelishvili equations.

   [1] A. Ananthanarayan, I. Caprini, J. Gasser and H. Leutwyler, *The scalar form factor of the pion*, work in progress.

2. We have nearly finished [1] our study of radiative K_{e3} decays in the framework of ChPT. In particular, we have shown that the value of the branching ratio published recently by the KTeV collaboration is not in agreement with the prediction of ChPT.

   [1] J. Gasser, B. Kubis, M. Verbeni and N. Paver, work in progress.

3. We have continued [1] the investigation of the hadronic contribution to the vacuum polarization in $g-2$ below 1 GeV and reported on the work in the conferences in Pisa and Bonn, see below (talks by G. Colangelo).

   [1] I. Caprini, G. Colangelo, F. Jegerlehner and H. Leutwyler, *The hadronic vacuum contribution to the $g-2$ of the muon*, work in progress.

4. We have worked on various topics concerning heavy quark physics:

   [1] H. M. Asatrian, K. Bieri, C. Greub and M. Walker, *Virtual- and bremsstrahlung corrections to $b \to d\ell^+\ell^-$ in the standard model*, Phys. Rev. D **69** (2004) 074007 [arXiv: hep-ph/0312063].

   [2] K. Bieri, *QCD corrections in inclusive rare B decays*, PhD Thesis, University of Bern, May 2004.

   [3] G. Eres, *Lepton mass effects in $B \to X_s\mu^+\mu^-$ and $B \to X_s\tau^+\tau^-$*, Diploma Work, University of Bern, November 2003.

[4] F. Borzumati, C. Greub and Y. Yamada, *Beyond leading-order corrections to* $\overline{B} \to X_s\gamma$ *at large* $\tan(\beta)$*: The charged-Higgs contribution*, Phys. Rev. D **69** (2004) 055005 [arXiv: hep-ph/0311151].

[5] F. Borzumati, C. Greub and Y. Yamada, *Beyond leading-order corrections to* $\overline{B} \to X_s\gamma$ *at large* $\tan(\beta)$*: The charged-Higgs contribution*, Phys. Rev. D **69** (2004) 055005 [arXiv: hep-ph/0311151].

[6] F. M. Borzumati and C. Greub, *2HDMs predictions for* $\overline{B} \to X_s\gamma$ *in NLO QCD*, Phys. Rev. D **58** (1998) 074004 [arXiv: hep-ph/9802391].

[7] S. Schilling, C. Greub, N. Salzmann and B. Toedtli, *QCD corrections to the Wilson coefficients C(9) and C(10) in two-Higgs-doublet models* [arXiv: hep-ph/0407323].

[8] A. Ali, E. Lunghi, and A.Ya. Parkhomenko, *Implication of the* $B \to (\rho, \omega)\gamma$ *branching ratios for the CKM phenomenology*, accepted for publication in Phys. Lett. B [arXiv: hep-ph/0405075].

[9] A. Ali, E. Lunghi, and A.Ya. Parkhomenko, *An analysis of the time-dependent CP asymmetry in* $B \to \pi\pi$ *decays in the standard model*, accepted for publication in Eur. Phys. J. C [arXiv: hep-ph/0403275].

[10] A. Ali and A.Ya. Parkhomenko, *An analysis of the inclusive decay* $\Upsilon(1S) \to \eta' X$ *and constraints on the* η'*-meson distribution amplitudes*, Eur. Phys. J. C **30** (2003) 183 [arXiv: hep-ph/0304278].

[11] A. Ali and A.Ya. Parkhomenko, *The* $\eta' g^* g^*$ *vertex including the* η'*-meson mass*, Eur. Phys. J. C **30** (2003) 367 [arXiv: hep-ph/0307092].

[12] T. Gehrmann, D. Maitre and D. Wyler, *Spin asymmetries in squark and gluino production at polarized hadron colliders* [arXiv:hep-ph/0406222].

[13] T. Huber, E. Lunghi,, M. Misiak and D. Wyler, *Electromagnetic logarithms in radiative B-decays*, work in progress.

[14] B. Tödtli, *QCD corrections to the Wilson coefficients for* $b \to s\ell^+\ell^-$ *in 2HDMs: Photonic contributions*, Diploma Work, University of Bern, August 2004.

[15] N. Salzmann, *QCD corrections to the Wilson coefficients for* $b \to s\ell^+\ell^-$ *in 2HDMs: Z-bosonic contributions*, Diploma Work, University of Bern, August 2004.

- *Future Experiments and identification of relevant hadronic quantities*

1. N. Cabibbo has recently suggested to determine the $\pi\pi$ scattering length $a_0 - a_2$ from $K_{3\pi}$ decays [1]. We are presently performing [2] an analysis of the situation in the framework of non relativistic effective field theories. The aim is to formulate a low energy theorem for the behaviour of the decay amplitude at threshold.

[1] N. Cabibbo, *Determination of the* $a_0 - a_2$ *pion scattering length from* $K^+ \to \pi^+\pi^0\pi^0$ *decay* [arXiv:hep-ph/0405001].

[2] G. Colangelo, J. Gasser, G. Isidori, B. Kubis and A. Rusetsky, work in progress.

Talks at International Conferences, Proceedings

1. G. Colangelo, *Hadronic vacuum polarization contribution to a_μ below 1 GeV*, invited talk given at *Chiral Dynamics Workshop CD2003* in Bonn, 8-13 Sep. 2003, in [B], p. 82.

2. G. Colangelo, *On the precision of the theoretical calculations for $\pi\pi$ scattering*, invited talk given at *Chiral Dynamics Workshop CD2003* in Bonn, 8-13 Sep. 2003, in [B], p. 88.

3. G. Colangelo, *Hadronic vacuum polarization contribution to a_μ*, invited talk given at *Workshop on Hadronic Cross Section at Low Energy*, Pisa, Italy, 8-10 October 2003 [arXiv: hep-ph/0312017].

4. G. Colangelo, *Finite volume effects in Chiral Perturbation Theory*, invited plenary talk given at the international conference *Lattice 2004*, Fermilab, June 2004, to appear in the Proceedings.

5. J. Gasser, A. Rusetsky and J. Schacher, *HadAtom03* [arXiv: hep-ph/0401204]. These are the Proceedings of the workshop *Hadronic Atoms*, Trento, Italy, 13-17 Oct 2003.

6. J. Schweizer, *Hadronic Atoms*, invited plenary talk given at *Chiral Dynamics Workshop CD2003* in Bonn, 8-13 Sep. 2003, in [B], p. 38.

7. J. Schweizer, *Energy shift and decay width of the πK atom*, invited talk given at the Workshop *HadAtom03* in Trento, 13-17 Oct. 2003, in [T], p. 25

8. P. Zemp, *Deser-type Formula for Pionic Hydrogen*, invited talk given at *Chiral Dynamics Workshop CD2003* in Bonn, 8-13 Sep. 2003, in [B], p. 128.

9. P. Zemp, *Deser-type formula for Pionic Hydrogen*, invited talk given at the Workshop *HadAtom03* in Trento, 13-17 Oct. 2003, in [T], p. 18.

10. J. Gasser, *Comments on $\bar{K}N$ scattering*, invited talk given at *Chiral Dynamics Workshop CD2003* in Bonn, 8-13 Sep. 2003, in [B], p. 126.

11. J. Gasser, *On the precision of the theoretical predictions for $\pi\pi$ scattering*, invited talk given at the Workshop *HadAtom03* in Trento, 13-17 Oct. 2003, in [T], p. 24.

12. J. Schweizer, *Spectrum and decays of hadronic atoms*, invited plenary talk given at *Meson04*, Kraków, June 4-8, 2004, to appear in the Proceedings.

13. J. Gasser, *Kaonic Atoms*, invited plenary talk given at *Dafne04: Physics at meson factories*, Frascati, June 7-11, 2004, to appear in the Proceedings.

14. A. Ali and A.Ya. Parkhomenko, *An analysis of the inclusive $\Upsilon(1S) \to \eta' X$ decay and constraints on the η'-meson distribution amplitudes*, invited talk given at the Int. Europhysics Conference on High-Energy Physics (HEP 2003), Aachen, Germany, 17-23 July 2003 [arXiv: hep-ph/0310256].

15. A. Ali and A.Ya. Parkhomenko, *The $\eta' g^* g^{(*)}$ vertex including the η'-meson mass*, invited talk given at the Int. Europhysics Conference on High-Energy Physics (HEP 2003), Aachen, Germany, 17-23 July 2003 [arXiv: hep-ph/0310250].

16. T. Hurth and W. Porod, *Non-diagonal flavour observables in B and collider physics*, invited talk given by W. Porod at the Int. Europhysics Conference on High-Energy Physics (HEP 2003), Aachen, Germany, 17-23 July 2003 [arXiv:hep-ph/0311075].

17. T. Hurth, E. Lunghi and W. Porod, *Untagged $B \to X/s+d$ gamma CP asymmetry as a probe for new physics*, arXiv:hep-ph/0312260.

[B] Ulf-G. Meißner, H. W. Hammer and A. Wirzba, Miniproceedings *Chiral Dynamics: Theory and Experiment (CD2003)* [arXiv:hep-ph/0311212].

[T] J. Gasser, A. Rusetsky and J. Schacher, *HadAtom03* [arXiv: hep-ph/0401204]. These are the Proceedings of the workshop *Hadronic Atoms*, Trento, Italy, 13-17 Oct 2003.

Presentations at meetings and conferences

1. B. Kubis, *A re-analysis of radiative K_{e3} decays*, Seminar talk given at the Helmholtz Institut für Strahlen- und Kernphysik (Theorie), University of Bonn, Germany, 8 Dec 2003.

2. B. Kubis, *A re-analysis of radiative K_{e3} decays*, Seminar talk given at the Institute for Theoretical Physics, University of Zürich, Switzerland, 28 Jan 2004.

3. B. Kubis, *A re-analysis of radiative K_{e3} decays*, Talk given at the Third Euridice Collaboration Meeting, University of Vienna, Austria, 13 Feb 2004.

4. B. Kubis, *A re-analysis of radiative K_{e3} decays*, Talk given at the Kaon Mini Workshop, CERN, Geneva, Switzerland, 5 May 2004.

5. B. Kubis, *What can we learn from radiative K_{e3} decays?*, Seminar talk given at the Paul Scherrer Institute, Villigen, Switzerland, 24 Jun 2004.

6. B. Kubis, *What can we learn from radiative K_{e3} decays?*, Seminar talk given at the Institut für Kernphysik, Forschungszentrum Jülich, Germany, 13 Jul 2004.

7. G. Colangelo, *Finite volume effects in masses and decay constants*, invited talk given at the Workshop *Matching Light Quarks to Hadrons*, Benasque, Spain, July 25-August 13 2004.

8. G. Colangelo, *$\pi\pi$ scattering at high energy: determination of Regge parameters*, invited talk given at *3rd Euridice collaboration meeting*, Vienna, Austria, 12-14 February 2004.

9. G. Colangelo, Invited lecture series on *Chiral Perturbation theory* at the *XXXV Arbeitstreffen Kernphysik*, Schleching, Germany February 26 - March 4, 2004.

10. Ch. Greub, *Inclusive Rare B decays*, invited seminar talk given at the Korea Institute for Advanced Study (KIAS), Seoul, March 9, 2004.

Joint Publications

1. G. Colangelo and S. Durr, *The pion mass in finite volume*, Eur. Phys. J. C **33**, 543 (2004) [arXiv:hep-lat/0311023].

   Nodes: Bern-DESY Zeuthen

2. A. Ghinculov, T. Hurth, G. Isidori and Y. P. Yao, *The rare decay $B \to X/s\ l+\ l-$ to NNLL precision for arbitrary dilepton invariant mass*, Nucl. Phys. B **685** (2004) 351 [arXiv:hep-ph/0312128].

   Nodes: Bern-Frascati

3.11 Universität Wien

Participant Number 11 : Vienna, Universität Wien

Gerhard Ecker (50%), Reinhold A. Bertlmann (50%), Katharina Durstberger (100%), Walter Grimus (25%), Beatrix C. Hiesmayr (100%), Roland Kaiser (100%, since Oct. 1, 2003), Helmut Neufeld (50%), Heinz Rupertsberger (25%, until June 30, 2004), Julia Schweizer (100%, since Aug. 1, 2004)

SCIENTIFIC STAFF

Total: 9 researchers ≡ 60 p-m/y

Scientific Highlights

A detailed numerical study of K_{e3} decays to $O(p^6, (m_d - m_u)p^2, e^2p^2)$ was performed [1]. We describe the extraction of the CKM matrix element $|V_{us}|$ from the experimental K_{e3} decay parameters. We propose a consistency check of the K^+_{e3} and K^0_{e3} data that is largely insensitive to the dominating theoretical uncertainties, in particular the contributions of $O(p^6)$. Our analysis is highly relevant in view of the current high statistics K_{e3} measurements.

The long-term project on isospin breaking in $K \to 2\pi$ decays was completed [2,3], including both strong isospin violation and electromagnetic corrections to next-to-leading order in the low-energy expansion. The impact of isospin violation on CP conserving amplitudes and rescattering phases was studied, leading in particular to a reliable value for the $\Delta I = 1/2$ ratio. We also analysed the effect of isospin violation on the CP violation parameter ϵ', finding destructive interference between three different sources of isospin violation.

Another major project has been started together with the Valencia node to investigate the matching of Green functions between the low-energy behaviour given by chiral perturbation theory and the high-energy structure dictated by QCD. In the spirit of large N_c, the Green functions in the intermediate-energy range are assumed to be given by meson resonance exchange. The matching yields values for some of the chiral low-energy constants of $O(p^6)$. First results were obtained for the three-point function of vector, axial-vector and pseudoscalar currents [4].

The chiral corrections to the current algebra prediction for the topological susceptibility of QCD were worked out (R. Kaiser, in preparation). For the observed values of the quark masses, our result implies a small correction to the leading-order value. It also serves as an improved prediction to compare to results from full QCD simulations on the lattice. In that connection, it may help to determine the low-energy constant L_7 from the lattice.

The Quantum Mechanics group had intense collaborations with the EURIDICE group in Barcelona [6,7,8,9,10,11] and with the Atominstitut of Austrian Universities in Vienna [12,13]. Based on work performed during the previous reporting period [R.A. Bertlmann, K. Durstberger, B.C. Hiesmayr, Phys. Rev. A 68 (2003) 0121111], the realization of an experiment determining the decoherence parameter was discussed with experts from the Institute for High Energy Physics of the Austrian Academy of Sciences.

With the collaborators in Barcelona the ideas of quantum marking and erasure for neutral kaons were worked out and the physics involved turned out to be very rich. Experimental setups were proposed which are analogous to other two-level systems [6]. However, contrary to other two-level systems the strangeness and lifetime of neutral kaons can be alternatively

measured via an "active" or a "passive" procedure and this offers new quantum erasure possibilities [8,9,10]. The interferometric duality was discussed and applied to the neutral kaon system [7]. This subject is of interest to be studied experimentally at DAΦNE.
The quantitative formulation of Bohr's complementarity was applied to physical situations for which analytical expressions are available [11]. This includes a variety of conventional double-slit experiments, but also particle oscillations (neutral kaons, B mesons) and Mott scattering of identical nuclei. For all these cases a unified description could be achieved. Moreover, the effective number of fringes which an experimenter can observe was predicted. With the Atominstitut group we proposed an experiment with neutron interferometry that connects the Berry phase, a geometric phase, with the violation of a Bell inequality, i.e. entanglement. The proposed dependence of the S-function on the Berry phase will be tested experimentally.

Publications

[1] V. Cirigliano, H. Neufeld and H. Pichl, K_{e3} decays and CKM unitarity, Eur. Phys. J. C35 (2004) 53. **Joint publication Valencia/Vienna.**
[2] V. Cirigliano, G. Ecker, H. Neufeld and A. Pich, Isospin violation in ϵ', Phys. Rev. Lett. 91 (2003) 162001. **Joint publication Valencia/Vienna.**
[3] V. Cirigliano, G. Ecker, H. Neufeld and A. Pich, Isospin breaking in $K \to \pi\pi$ decays, Eur. Phys. J. C33 (2004) 369. **Joint publication Valencia/Vienna.**
[4] V. Cirigliano, G. Ecker, M. Eidemüller, A. Pich and J. Portolés, The $\langle VAP \rangle$ Green function in the resonance region, Phys. Lett. B596 (2004) 96. **Joint publication Valencia/Vienna.**
[5] G. Ecker, Radiative corrections for $\tau \to \nu_\tau \pi\pi$, Nucl. Phys. B (Proc. Suppl.) 131 (2004) 143.
[6] A. Bramon, G. Garbarino and B.C. Hiesmayr, Quantum marking and quantum erasure for neutral kaons, Phys. Rev. Lett. 92 (2004) 020405 (also selected for Virtual Journal of Quantum Information, Feb. 2004, vol. 4, issue 2). **Joint publication Barcelona/Vienna.**
[7] A. Bramon, G. Garbarino and B.C. Hiesmayr, Quantitative duality and neutral kaon interferometry in CPLEAR experiments, Eur. Phys. J. C32 (2004) 377. **Joint publication Barcelona/Vienna.**
[8] A. Bramon, G. Garbarino and B.C. Hiesmayr, Active and passive quantum eraser for neutral kaons, Phys. Rev. A 69 (2004) 062111. **Joint publication Barcelona/Vienna.**
[9] A. Bramon, G. Garbarino and B.C. Hiesmayr, Passive quantum eraser for neutral kaons, Proc. of "Symmetries in Gravity and Field Theory", Salamanca, Spain, June 2003, to be published by "Ediciones Universidad de Salamanca"; quant-ph/0404086. **Joint publication Barcelona/Vienna.**
[10] A. Bramon, G. Garbarino and B.C. Hiesmayr, Quantitative duality and quantum eraser for neutral kaons, Workshop on e^+e^- in the 1-2 GeV range, Alghero, Italy, September 2003 (eConf C0309101); hep-ph/0311232. **Joint publication Barcelona/Vienna.**
[11] A. Bramon, G. Garbarino and B.C. Hiesmayr, Quantitative complementarity in two-path interferometry, Phys. Rev. A 69 (2004) 022112. **Joint publication Barcelona/ Vienna.**
[12] R.A. Bertlmann, K. Durstberger, Yuji Hasegawa and B.C. Hiesmayr, Berry phase in entangled systems: an experiment with single neutrons, Phys. Rev. A 69 (2004) 032112

(also selected for Virtual Journal of Quantum Information, April 2004, vol. 4, issue 4).
[13] B.C. Hiesmayr, Bell inequalities for the neutral kaon system, in Proc. of "Quantum Theory: Reconsideration of Foundations-2", Växjö, Sweden, June 2003; quant-ph/0311179.
[14] K. Durstberger, Berry phase in an entangled spin-1/2 system, in Proc. of "Quantum Theory: Reconsideration of Foundations-2", Växjö, Sweden, June 2003.

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. An investigation of the one-loop functional of chiral SU(2) with virtual photons and leptons is in progress. Together with the Bern group (H. Leutwyler), we work on a determination of the ratio of the strange to the mean up and down quark masses in the framework of chiral perturbation theory with a large number of colours. Due to the absence of the Kaplan–Manohar ambiguity in this setting, it is possible to express this ratio in terms of experimentally observable quantities. Together with R. Unterdorfer who finished his doctoral thesis in Frascati during this reporting period, the strong and nonleptonic weak functional of chiral SU(3) will be presented in closed form including one-loop amplitudes with up to three propagators. An easy-to-use Mathematica program for both strong and weak amplitudes to $O(p^4)$ will be offered to the chiral community. The general problem of bridging the gap between low and high energies for Green functions will be further investigated together with the group in Valencia. The most general resonance couplings contributing to low-energy constants of $O(p^6)$ will be constructed and subjected to high-energy constraints from QCD.
The Quantum Mechanics group is continuing the collaborations with the different groups. With the EURIDICE group in Barcelona an article about Bell inequalities in particle physics is in preparation. Different decoherence models and their connections to familiar entanglement measures are under further investigations. It will be discussed if the experimental data of B meson experiments (BaBar, BELLE) or of K mesons (DaΦne) can be used for testing the different models. The possibility will be investigated whether the requirement of "complete positivity" can be tested experimentally. This requirement plays an important role in the effective quantum-mechanical description of the time evolution of open systems. We speculate about a possible test with random magnetic fields.

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, except that Heinz Rupertsberger from our permanent staff has retired. The Euridice postdoc of our group, Roland Kaiser, who started his appointment on Oct. 1, 2003, will work full-time for the project until Sept. 30, 2005. We could also welcome Julia Schweizer on Aug. 1, 2004 who has joined our group with a fellowship from the Swiss National Science Foundation until July 31, 2005.

Organization and Management

Our group organized the 3rd Collaboration Meeting in Vienna from Feb. 12 - 14, 2004 with 66 participants from all nodes. The list of participants, the scientific program and the conference poster can be found at the end of this report. In addition, the Vienna group has communicated their results at various international meetings, workshops and schools: Chiral Dynamics 2003 (Bonn, Germany, Sept. '03), Quarks in Hadrons and Nuclei II (Oberwölz, Austria, Sept. '03), Triangle Graduate School (Raach, Austria, Sept. '03), Workshop on Hadronic Cross Sections at Low Energies (Pisa, Italy, Oct. '03), Winter School on Quantum Coherence in Matter: From Quarks to Solids (Schladming, Austria, Feb. '04), Lattice QCD and Effective Field Theories (Berlin, Germany, April '04), Int. Workshop on Large-N_c QCD (Trento, Italy, July '04). Gerhard Ecker and Roland Kaiser spent 2 weeks at the Valencia Institute in April 2004.

Secondment

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

Training

The postdoctoral position of the Vienna node was awarded to Dr. Roland Kaiser (Switzerland) who took up his appointment on Oct. 1, 2003 and will stay until Sept. 30, 2005.

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%), P. Jankowski (Ph.D. Students, Warsaw) and A. Grzelińska, E. Nowak (Ph.D. Students, Katowice) (3x7 pm/y=3x58%) Total: 8 researchers

Scientific Staff

Scientific Highlights

Katowice-Karlsruhe-Valencia collaboration resulted in a number of new developments helping in hadronic cross section measurements via radiative return method at meson factories. After calculating next-to-leading order radiative corrections to final state emission for pion pair production, and their implementation in PHOKHARA Monte Carlo event generator [1], the results were disseminated and physical analysis deepened in [2, 3]. Possible background to radiative pion pair production from additional electron pair emission was investigated in [4]. A number of new physical measurements and tests of existing models of hadronic interactions, possible due to radiative return method, was proposed in [5]. One example, separate magnetic and electric nucleon form factors measurement, was studied in detail in [6, 7], were its feasibility at B factories was demonstrated. Next-to-leading order radiative corrections to final state photon emission in the process $e^+e^- \to \mu^+\mu^-\gamma(\gamma)$, relevant for radiative return method, where the radiative muon pair production serves as luminosity monitoring process, were calculated and implemented into PHOKHARA Monte Carlo event generator in [8]. A new efficient method of using differential equations to calculate scalar integrals, relevant for calculation of two-loop radiative corrections, nearby singular points was developed by Katowice-Bologna collaboration [9].

S. Wycech worked on new experimental proposals among others on K-D atoms, AIC project for new GSI Darmstadt [10]. This is related to a fresh KEK discovery (T.Suzuki et al., Phys Lett B597,263) of a strongly bound K-NNN system. It is apparently related to subthreshold K-N anplitude and may be tested in K-D, K-He atoms. Eta-pi mixing close to the eta-helium threshold was studied in [11].

A pion form factor phase,$\pi\pi$ elasticity and new e+e- data, which are important for the interpretation on $g-2$ data was studied in [12]. A sum rule of superconvergence type for parity violating amplitudes (p.v. analogue of Gerasimov-Drell-Hearn sum rule) [13] was discussed. The parity violating polarized photon-induced processes for proton target are considered in the frame of effective low energy theories and phenomenological models based on p.v. nucleon-meson effective interactions.

We continued study of the partonic structure of photon, especially its heavy quark content. We constructed a LO and NLO order parton parametrization for a photon [7, 8, 9]. This is of primary importance for testing hadronic interaction of photon [15, 17], as well as for a reliably estimation of the background processes for the Higgs production at future Photon Linear Collider (PLC). [16]

The first step of the $\mathcal{O}(\alpha_s^2)$ calculation of the $\bar{B} \to X_s\gamma$ decay rate amounts to finding three-loop corrections to the electroweak-scale values of the Wilson coefficients of the

relevant flavour-changing operators. Such a calculation was completed in the paper [10]. Several hundreds of massive three-loop diagrams were evaluated for that purpose. Different masses of the top quark (m_t) and the W-boson (M_W) were taken into account by applying expansions in M_W^2/m_t^2 and $(m_t^2 - M_W^2)/m_t^2$.

Networking

Visiting scientists from or at other EURIDICE nodes:

- Leszek Łukaszuk and Maria Krawczyk participated in the Third Collaboration Meeting in Wien (February 2004); talk by Łukaszuk based on [12]
- Maria Krawczyk took part in the Executive Committee Meeting, Paris (5th December 2003)
- H. Czyż visited Bologna (INFN i Departimento di Fisica, Universita di Bologna): 2 weeks in september 2003, 1 month January/February 2004
- H. Czyż visited Frascati (LNF) - 2 weeks in February 2004
- H. Czyż visited Karlsruhe (TTP, Karlsruhe Univ.) - 3 months (October-December 2003)
- A. Grzelińska visited Frascati (LNF) - 2 weeks February 2004
- A. Grzelińska visited Karlsruhe (TTP, Karlsruhe Univ.) - 2 months (October-November 2003)
- E. Nowak visited Karlsruhe (TTP, Karlsruhe Univ.) - one month (November 2003)
- S.Wycech visited Vienna (Interm En. Phys.) August 2004
- Mikołaj Misiak visited U. of Zurich in September 2003 and DESY Zeuthen in March 2004. None of these visits was supported by the Euridice network.

Conferences

- A. Grzelińska, H. Czyż, E. Nowak, M. Krawczyk participate in the topical conference organized by Katowce team " 27th International Conference of Theoretical Physics: Matter to the Deepest: Recent Developments in Physics of Fundamental Interactions (Ustroń 03)", Ustroń, Poland, 15-21 Sep 2003; Talks based on [2, 4]
- H. Czyż participated in "Workshop on e+ e- in the 1-GeV to 2-GeV Range: Physics and Accelerator Prospects - ICFA Mini-workshp - Working Group on High Luminosity e+ e- Colliders", Alghero, Sardinia, Italy, 10-13 Sep 2003; talks based on [3]
- E. Nowak participated in "DAFNE 2004: Workshop on Physics at Meson Factories", Rome, Frascati, Italy, 7-11 Jun 2004; talk based on [7]

- Slawomir Wycech participated in conference "Meson 04" Krakow (June 2004); talk based on [11]

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1. H. Czyż, A. Grzelińska, J. H. Kühn and G. Rodrigo, "The radiative return at Phi and B-factories: FSR at next-to-leading order," Eur. Phys. J. C **33** (2004) 333 [hep-ph/0308312].

2. H. Czyż and A. Grzelińska, "FSR at leading and next-to-leading order in the radiative return at meson factories," Acta Phys. Polon. B **34** (2003) 5219 [hep-ph/0310341].

3. H. Czyż and A. Grzelińska, "Hadronic cross section from radiative return," eConf C0309101:FRWP007,2003 [hep-ph/0402030].

4. H. Czyż and E. Nowak, "e+ e- → pi+ pi- e+ e-: A potential background for sigma(e+ e- → pi+ pi-) measurement via radiative return method," Acta Phys. Polon. B **34** (2003) 5231 [hep-ph/0310335].

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8. H. Czyż, A. Grzelińska, J. H. Kühn and G. Rodrigo, "The radiative return at Phi- and B-factories: FSR for muon pair production at next-to-leading order", hep-ph/0404078.

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10. S. Wycech " The interest in kaonic-deuterium atoms", e-Print Archive: nucl-th/0408066

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1. Henryk Czyż, Agnieszka Grzelińska, Johann H. Kuhn, German Rodrigo, "The radiative return at Phi and B-factories: FSR at next-to-leading order," Eur. Phys. J. C **33** (2004) 333 [hep-ph/0308312].
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