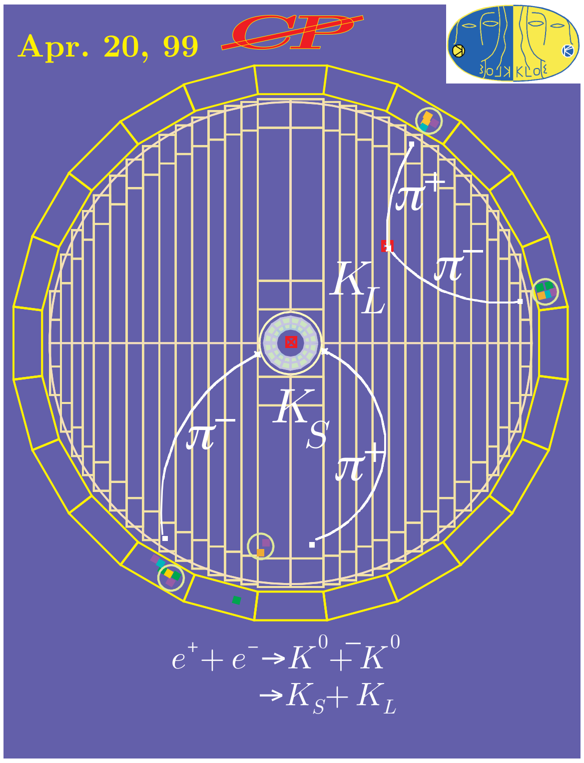
EURODAPHNE
High Precision Elementary Particle Physics at the ϕ -factory DAΦNE

Annual Progress Report

April 1st 1998-March 31st 1999



The first CP-violating Event Observed at DAΦNE in the KLOE Detector

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1 Network Progress

EURODAPHNE is a network which studies the breaking of certain fundamental laws of symmetry, among them Charge and Parity (CP), Charge Parity and Time reversal (CPT) invariance, chiral symmetry, SU(3) symmetry, isospin in hypernuclear nuclear reactions. This study will compare theoretical expectations with precision measurements from the experiments at the ϕ-factory DAΦNE in Frascati, also in relation with other planned or existing experiments, if relevant to this physics program. In particular, the central program of the study of CP violation is being carried through not only and mostly studying the K-meson system, but also, albeit to a lesser extent, through the B-meson system.

The theoretical program is proceeding alongside the experimental one, now in a good advancement stage. Since April 1999, the detector KLOE is inserted and working in the accelerator DAΦNE and the line shape of the ϕ-resonance has been observed, together with the first events in radiative Bhabha scattering, and $\phi \to K_S K_L$.

1.1 Comparison with our Work Program

Our stated research objectives were : RESEARCH OBJECTIVES

1. To help clarify the origin of CP violation.
2. To sharpen existing predictions of Chiral Perturbation Theory.
3. To improve the understanding of rare kaon decays and possibly to disentangle short distance effects.
4. To investigate the implications of precision data on $e^+e^- \to$ hadrons at low energy from both the experimental and the theoretical point of view.
5. To understand the nature of the enigmatic scalar mesons which appear just below 1 GeV and which are produced in radiative ϕ-decays.
6. To investigate the interactions of strange and light quarks in baryons and nuclear matter, in particular the properties of strange nuclei, hypernuclei, formation of kaonic atoms and KN scattering at threshold.

1. CP VIOLATION

Concerning the **first** of the above stated research objectives, an important event affecting our program has been the announcement, in February 1999, of the observation of direct CP violation at FermiLab by the KTeV collaboration, which reported ϵ'/ϵ =(28 $\pm 4.1) \times 10^{-4}$, a value higher, by almost one order of magnitude, than the central value of the most recent theoretical calculations, thus rekindling the theoretical interest in the measurement by DAΦNE. We report here progress alongside the following directions:

a) A first step towards a controlled analytical evaluation of ϵ'/ϵ in the Standard Model, using the large-N_c limit of QCD, has been obtained.

b) Detailed calculations have been performed of the strange quark mass corrections to hadronic τ-decay width which will allow one to determine the value of m_s, a parameter whose numerical value is very important in the determination of ϵ'/ϵ .

c) Significant progress toward the calculation of ϵ'/ϵ has been obtained with a method of obtaining $K \to \pi\pi$ from off-shell $K \to \pi$ amplitudes. Within the expected error the main part of the experimental $\Delta I = 1/2$ amplitude has been reproduced, attaining a first major test of the method.

d) A theoretical reappraisal of the extraction of certain CKM matrix elements from semileptonic B-decays has been completed .

e) New CP-violating observables in B-decays into hyperon-antihyperon which would allow one to resolve some discrete ambiguities in the CP angles of the unitarity triangle, have been proposed.

Concerning the **second** objective, work has progressed as follows: **2.** CHPT

a) The effective chiral lagrangian has been constructed at next–to–next–to leading order, and the divergence structure of the low–energy constants at order p^6 have been determined. This will allow one to check any future explicit two–loop calculation in the meson sector against these results.

b) A significant step has been taken towards the goal of working out the prediction for the threshold parameters of $\pi\pi$ scattering in the framework of standard Chiral Perturbation Theory, through the complete understanding of the mathematical properties of the system in the one and multi-channel cases. The tools that will allow one to extract the S-wave $\pi\pi$ scattering length from the KLOE data on K_{l4}-decays, are the so-called Roy equations, for which new numerical solutions have been generated and are available for direct comparison with data

b) The chiral expansion has been extended in a systematic manner to the η'-meson, the heaviest of the pseudoscalar mesons.

d) Within the framework of Generalized Chiral Perturbation theory, theoretical investigation of chiral symmetry breaking in "vector like" gauge theories has been carried out.

e) Electromagnetic corrections to $\pi\pi$ scattering have shown that virtual electromagnetic effects are comparable in size to chiral two loop effects and must therefore be taken into account in future phenomenological analyses. An analysis of e.m. corrections in K-semileptonic decays is in progress.

f) Models linking Chiral Perturbation Theory and QCD in the large N_c limits have been explored with interesting results regarding the e.m. pion mass difference and weak matrix elements

g) Unitarization effects in hadronic processes have resulted in the resummation of chiral logarithms, an important phenomenon in the scalar sector

h) Effective lagrangians in the resonance region have been studied, by explicitly incorporating matter fields in the lagrangian The theoretical basis for an extended low-energy effective theory has now been worked out up to one-loop level, by including the photon and the light leptons as explicit degrees of freedom. This will allow a complete analysis of the electromagnetic corrections for the semileptonic decays of the light pseudoscalars.

i) Chiral corrections to the vector decay constants have been done, thus improving our understanding of the inclusion of vector mesons in Effective Lagrangians

j) General methods for evaluating two-loop integrals encountered in Chiral Perturbation Theory have been reported.

k) In pion-nucleon chiral perturbation theory, a powerful method that allows one to perform calculations in a manifestly Lorentz invariant way has been developed. The method is an alternative to the so called Heavy Baryon Chiral Perturbation Theory.

l) We have now a better understanding of weak matrix elements and the relative role of unitarity corrections and local contributions in non-leptonic Kaon-decays.

3. RARE K-DECAYS

Concerning the understanding of rare Kaon decays (**third objective**) progress was mainly obtained in the areas :

a) In the study of rare decays beyond the Standard Model, it has been shown that the branching ratios of $K \to \pi\nu\bar{\nu}$ and $K_L \to \pi^0 e^+ e^-$ decays could be substantially increased in specific supersymmetric extensions of the Standard Model. The upper bounds obtained in this scenario for $B(K_L \to \pi^0\nu\bar{\nu})$ are not far from the expected KLOE sensitivity.

b) A detailed analysis of the CP conserving contribution to $K_L \to \pi^0\nu\bar{\nu}$ has been carried out showing that, although sensitive in part to nonperturbative physics, this contribution is rather well under control and turns out to be negligible. This enforces the role of the $K_L \to \pi^0\nu\bar{\nu}$ in probing CP violation and short-distance dynamics.

c) A model-independent analysis of $K^+ \to \pi^+\ell^+\ell^-$ and $K_S \to \pi^0\ell^+\ell^-$ decays has been performed, including $K \to 3\pi$ unitarity corrections and a general decomposition of the dispersive amplitude. Consequences for the $K^\pm \to \pi^\pm e^+ e^-$ charge asymmetries and for the $K_L \to \pi^0 e^+ e^-$ mode have been investigated. The decay $K_L \to \pi^+\pi^- e^+ e^-$, with interesting CP violating asymmetries, is being recalculated to $O(p^4)$.

d) A study of the CP-conserving contribution to the transverse muon polarization in the decay $K- > \mu\nu\gamma$, an interesting T-violating observable, that vanishes in the Standard model at tree level, has been done.

4. $e^+e^- \to$ HADRONS

The **fourth** area of scientific interest, has progressed considerably, since the formulation of our work program. The problem concerns the e^+e^-– hadronic cross-section, which provides information on the hadronic contributions to $(g-2)_\mu$ and $\alpha_{\rm QED}(M_Z)$. Progress has been along different directions :

a) *Theoretically.* Investigations of the validity of perturbative QCD at low energy have led to a new approach – based on Euclidean Quantum Field Theory – which demonstrates that the data from DAΦNE can substantially improve not only our knowledge of the anomalous magnetic moment of the μ but also that of running of the e.m. coupling constant.

b) *Phenomenologically.* There has been intense work to investigate the possibility of studying the cross-section by tuning the energy of the final hadronic state through emission of hard photons from the initial state, in view of the fact that DAΦNE will operate at a fixed energy corresponding to the ϕ-resonance and thus would not otherwise be able to contribute to the region of interest. The phenomenological studies have demonstrated the feasibility from the statistical and systematics point of view, by showing that the cross-section with a hard photon will be large enough to allow a reduction of the error, and that the background due to final state radiation can be kept under control by appropriate cuts.

c) *Monte Carlo techniques.* Simulation has progressed with the preparation of a Monte Carlo program for $e^+e^- \to \gamma$ + hadrons,

d) *Radiative corrections.* Work necessary to obtain the required precision of the measurement is also advanced, with a Monte Carlo program BABAYAGA for Large angle Bhabha scattering.

5. SCALAR MESONS

Concerning the **fifth** of our research objectives, work has progressed both along the lines described, but also by addressing the question of the pseudoscalar mesons, where the study of η and η' radiative formation through the ϕ as well as their decay properties are now appearing to be more and more interesting, thanks to new theoretical development both inside and outside the network. The progress is about :

a) The scalar resonances, which are candidates for exotic mesons and glueballs, have received new attention from the question of whether the light and broad $\sigma(500)$ exists, in particular through the study of the well known sigma model and a comparison of its predictions with present data.

b) The related issue of the ninth (singlet) pseudoscalar meson has been analyzed and results have been obtained on the classical subject of η and η' mixing.

c) The feasibility of studying the transition form factors and the radiative width of π^0 and η through $\gamma\gamma$ reactions in the KLOE detector, has been reexamined.

6. BARYONS AND NUCLEAR MATTER

Finally, concerning the **last** of the indicated objectives the activity has brought around the following results :

a) Predictions have been made for the K-N interaction with all coupled channels. A many-body theory for K-nucleus interactions has been done and agreement with present data on K-atoms found to be excellent. Predictions for deeply bound kaonic atoms have been made.

b) Extensive predictions for the decays of hypernuclei, to be observed at DAΦNE , have been prepared as a guide for future experiments.

c) Work in the pion-nucleon sector has been of phenomenological relevance, and related to the subthreshold behavior of the pion-nucleon system.

d) progress in the chiral description of the pion-nucleon system has been remarkable, as indicated above while discussing Chiral Perturbation Theorywork.

MAIN HIGHLIGHTS

The progress achieved in the last 12 months is characterized by the following **highlights**.

- As a result of the close collaboration between scientists in the various European nodes, a number of very significant steps towards a refined formulation of Chiral Perturbation Theory as the theory of fundamental interactions in the non-perturbative regime could be performed.
- To illustrate the progress made with a few examples, we mention that
  - the effective lagrangian in the meson sector is now known explicitly at next–to–next–to leading order,
  - the structure of the solutions to Roy's integral equations has been explored analytically and numerically (this will be of great relevance in the analyses of K_{l4}–decays measured at DAFNE),

– a powerful method has been developed, that allows one to analyze the meson–baryon system at low energies in a systematic and straightforward manner.

- We have finalized the feasibility studies to measure with the required precision the hadronic electron-positron cross-section in the low–energy region.

These highlights, together with all the other very important progress, are in the stated objective to extract fundamental information from the high precision data in the region of very low-momentum interactions between elementary particles. The aim is to arrive to a theoretical description of low energy phenomena between elementary particles and to establish the mathematical tools that allow one to evaluate physical quantities in the non-perturbative regime of QCD, the theory of strong interactions. The work performed by the network during its first year of operation has progressed in this direction.

These results have been obtained in part through individual work, but mostly through networking activities, which included some of the following : NETWORKING

a) Collaboration Meetings : two Collaboration Meetings took place during the first 12 months. The transparencies of all the talks presented at these meetings have been collected and bound in a volume distributed to all participants. Participants included members from all the network node and also some invited speakers from outside the network, whose expertise was relevant to the work project. In Appendices A and B, for each of the two Collaboration Meetings, we have reproduced the posters which were circulated among the community, the list of participants and the Program of the Meetings. The two meetings were

   1. the VII EURODAΦNE Collaboration Meeting, held in Frascati Laboratories from 14 to 18th of April 1998, together with the 1998 LNF Spring School, attended, among others, by young researchers from the network
   2. and the VIII EURODAΦNE Collaboration Meeting in Paris, at Laboratoire de Physique Nucleaire et de Hautes Energies from 19 to 21st of October 1998

b) Workshops or Working Groups Meetings: two such working Group meetings were organized, i.e.

   1. Bern Workshop on K_{l4}-decays, to study how to extract the information on the pion-pion scattering lengths from the upcoming K-decay measurements at DAΦNE . Participation to this meeting involved scientists from Durham, Paris, Bern, Zurich. A summary of this activity was published in the web page of the network
   2. Frascati meeting for radiative corrections to luminosity and the measurement of the hadronic cross-section at DAΦNE held in Frascati on October 6th 1998

c) Visits among the nodes for collaborative efforts on specific research subjects, in particular there have been various exchanges between Frascati and Granada, Frascati and Rutherford Laboratory, Oxford, Naples and Vienna, etc.

d) A coordination meeting was organized in Frascati on February 20th 1999 between the members of the Executive Committee of the Network to finalize the hiring of the young researchers. The meeting was very successful in defining a general strategy for this and the following year. A summary of the meeting decisions was circulated among the teams afterwards.

Table 1: Status of EURODAPHNE Training Plan

N.º –	Team –	person-months Post Doc	person-months Doct. Stud.	Presently Hired	Starting after April 1999
1	INFN-LNF	36	18	G. Hiller 12 (post-doc)	R. Escribano 24(post-doc)
2	UKRAL	36	30	K. Benhaddou 12 (Ph.D. stu.)	F. De Fazio 24 (post-doc) G. Garbarino 6 (PhD)
3	CNRS-IN2P3	12	12		
4	CNRS-CPT	24	–		
5	UAB	24	–		J. Charles 24(postdoc)
6	UVEG	24	–		L. Scimeni 24 (post-doc)
7	UWIEN	24	–	G. Mueller 24 (post-doc)	
8	DESY-ZEU	36	–	G. Venanzoni 18 (post-doc)	
9	UHELS	36	–	G. Amoros 24 (post-doc)	
10	UBERN	24	–		A. Rusetsky 24 (post-doc)
Total	–	276	60	90	126

e) a Web page, http://www.lnf.infn.it/theory/tmr/, was published very early on, following the well established practice of this group of accessing the joint work from the web. Each node is linked through the page and all the papers sent by the members of the Collaboration to the international Bulletin Boards or to the web page, can be accessed. Meetings of general interest and post-doc positions are also advertised there.

1.2 Appointment of Young Researchers

Vacant positions in the network were advertized both by posting the vacancies in the web page, but mostly by sending the notice to the Secretariat of the CERN theoretical group which distributes the information throughout Europe. The young researchers and some of the interesting applicants were invited, and partly financed, to participate to the LNF Spring School in April 1998. Following this, some hiring was done. To fulfill other network vacancies and following Europe-wide advertisement of the positions as indicated, a meeting was held in Frascati in February 1999, to finalize the hiring decisions for the incoming period. In the following table we show the present status of the training plan in comparison with the same table in the work plan. We notice that by december 1999 64% of all the positions will have been filled. As for the remaining positions, the network will start another call for positions during the coming months, with a possible deadline for application in October 1st 1999.

1.3 Interactions with Industry

As noted in the work program, this network mostly consists of theoretical physicists concerned with elementary particle physics. As such, interactions with industry are not a part of the expected outcome. However,our physics efforts are connected to the experimental program which, through the detectors and the machine, have interacted with industry, mostly in Italy, but also in other member states.

1.4 Difficulties Encountered

From the point of view of the physics program or the interactions amongst participants or the progress of the network as such, no difficulties have been encountered. Relative to what is stated in the work program, there has been a slight delay in the beginning of the experimental program, since the machine DAΦNE began operating with the KLOE detector in place in April 1999 and collection of data for physics studies is now expected starting July 1999.

The difficulties we may encounter in the coming months concern the financing of the fellowship program in one of the nodes, namely the one based at the University of Vienna.

The University of Vienna does not provide its institutes with a central accounting of research funds. Therefore, the Institute for Theoretical Physics has to administer the funds for the EURODAPHNE-Network itself. This node is therefore completely dependent on the timely transfer of this money from the EU to fulfill their financial obligations related to the training plan of the Network. A letter from Prof. G. Ecker asking for transfer of a second installment with the same amount as the first one (41100 Euro) to be able to finance their operation, is enclosed with this report.

2 Factual Information

2.1 Scientific Specialty

The Scientific Specialty of this projects concerns :

P-01 Elementary Particle Physics

P-02 Nuclear Physics

P-03 Atomic and Molecular Physics

2.2 Total Research Effort

The total number of research staff contributing to the joint activities of the network is reported in Annex B for each node and in Annex C for the whole network. More detailed information on the contribution of researchers from individual nodes can be found in Section 4 of this report.

2.3 Fellowships

Following what is stated in Table 1 as well as in Annex B, we provide in Table 2 a summary of the factual informations concerning the young researchers which have been financed by the contract during the first reporting period. Here follows the list of publications of the

Table 2: Factual Information About Young Researchers financed by the Contract

Node	Name	Nation	Birth	Start	Duration	Category	Speciality
1	G. Hiller	De	24-10-66	1-10-98	12 mo	PD	P01
2	K. Benhaddou	Fr	20-11-73	1-10-98	12mo	PhD	P01
7	G. Mueller	De	18-10-67	1-11-98	24mo	PD	P01
8	G. Venanzoni	It	17-05-69	1-01-99	18mo	PD	P01
9	G. Amoros	Es	27-01-71	1-11-98	24mo	PD	P01

above named researchers.

[G. Hiller]

1. **A theoretical reappraisal of branching ratios and CP asymmetries in the decays $B \to (X_d, X_s)\ell^+\ell^-$ and determination of the CKM parameters.** By A. Ali and G. Hiller, DESY-98-187, LNF-98/041(P), December 1998, hep-ph/9812267, accepted for publication in Eur.Phys.J.C.
2. **The CP-conserving contribution to the transverse muon polarization in $K^+ \to \mu^+\nu\gamma$** By Gudrun Hiller and Gino Isidori, LNF-99/007(P), March 1999, hep-ph/9903284, accepted for publication in Phys. Lett. B.

[G. Mueller]

Virtual photons in baryon chiral perturbation theory by G. Müller and U.G. Meißner, hep-ph/9903375, submitted to Nucl. Phys. B.

[G. Amoros]

A Parametrization for $K^+ \to \pi^+\pi^-e^+\nu$
G. Amoros and J. Bijnens , LU-TP-99-05, 18p., hep-ph/9902463, submitted to J. Phys.

2.4 Seconded Staff

No staff was seconded from one node to the other. Collaborations developed through short visits, electronic mail, meetings at various Workshops organized by network participants or of common interest.

3 List of Joint Publications

Here follows for the network as a whole, a list of joint publications resulting from the joint activities of the network, i.e. publications involving two or more participants. We shall also indicate which of the participants is involved in each publication by the node number as defined in Annex I, Part A of the Contract. All the listed papers have appeared in refereed journals.

Joint Publications in Refereed Journals

1. G. D'Ambrosio, G. Ecker, G. Isidori and J. Portolés, *The decays $K \to \pi\ell^+\ell^-$ beyond leading order in the chiral expansion*, J. High Energy Phys. **08**, 004 (1998)
1-6-7

2. G. D'Ambrosio and J. Portolés, *Spin–1 resonance contributions to the weak Chiral Lagrangian : the vector field formulation*, Nuclear Physics, **B533** (1998) 494–522
1-6

3. G. D'Ambrosio and J. Portolés, *Analysis of* $K_L \to \pi^+\pi^-\gamma$ *in Chiral Perturbation Theory*, Nuclear Physics, **B533** (1998) 523–554
1-6

4. G. Colangelo and G. Isidori, *Supersymmetric contributions to rare kaon decays: beyond the single mass insertion approximation*, J. High Energy Phys. 09, 009 (1998)
1-10

5. S. Peris, M. Perrottet and E. de Rafael, *Matching Long and Short Distances in Large-*N_c *QCD*, JHEP **05** (1998) 011
4-5

6. M. Knecht, S. Peris and E. de Rafael, *Matrix Elements of Electroweak Penguin Operators in the* $1/N_c$ *Expansion,* hep-ph/9812471 (to appear in Phys. Lett. **B**)
4-5

7. M. Knecht, S. Peris and E. de Rafael," *The Electroweak* $\pi^+ - \pi^0$ *mass difference and weak matrix elements in the 1 / N(c) expansion* Phys. Lett. **B443**, 255 (1998)
4-5

8. J. Bijnens, E. Pallante and J. Prades, *Obtaining* $K \to \pi\pi$ *from off-shell* $K \to \pi$ *amplitudes* Nucl. Phys. **B521**, 305 (1998)
5-9-10

9. T.S. Lee, J.A. Oller, E. Oset and A. Ramos, *Nonperturbative chiral approach to* $K - p \to \gamma Y$ *reactions* Nucl. Phys. **A643**, 402 (1998)
5-6

10. E. Oset, J.A. Oller, J.R. Pelaez and A. Ramos, *Meson-meson and meson - baryon interactions in a chiral nonperturbative approach* Acta Phys. Polon. **B29**, 3101 (1998)
5-6

11. E. Oset and A. Ramos, *Weak decay of Lambda hypernuclei* Progr. Part. Nucl. Phys. **41** 191 (1998)
5-6

12. A. Pich and J. Prades, *Perturbative quark mass corrections to the tau hadronic width* JHEP **06**, 013 (1998)
5-6

13. A. Ramos, A. Parreno, C. Bennhold, E. Oset, L.L. Salcedo and M.J. Vicente-Vacas, *Non-mesonic weak decay of Lambda hypernuclei* Nucl. Phys. **A639**, 307 (1998)
5-6

14. E. Oset and A. Ramos, *Non perturbative chiral approach to s-wave anti-K N interactions* Nucl. Phys. **A635**, 99 (1998)
5-6

15. H. Neufeld, J. Gasser and G. Ecker, *The one-loop functional as a Berezinian*, Phys. Lett. **B438** (1998) 106
7-10

16. J. Bijnens, G. Colangelo and G. Ecker, *Double chiral logs* Phys. Lett. **B441** (1998) 437
7-9-10

17. J. Bijnens, G. Colangelo and G. Ecker, *The mesonic chiral Lagrangian of* $O(p^6)$ JHEP **02** (1999) 02
7-9-10

18. J. Bijnens P. Gosdzinsky and P. Talavera, *Chiral Corrections to Vector Meson Decay Constants* Phys. Lett. **429** (1998) 111
5-9

19. J. Bijnens G. Colangelo and P. Talavera, *The Vector and Scalar Form Factors of the Pion to Two Loops* JHEP **05** (1998) 014
1-5-9

20. J. Bijnens J. Prades, *The* $\Delta I = 1/2$ *Rule in the Chiral Limit* JHEP **01** (1999) 023
5-9

21. J. Gasser and M.E. Sainio, *Two-loop integrals in chiral perturbation theory* **Eur. Phys. J.** C6 (1999) 297
9-10

4 Reports from the individual nodes

For information, we report in what follows a short description of the activity from each individual node, inclusive of all their publications, let them be joint or not. These descriptions have not been prepared in a uniform fashion, as their contribution to this report was not required. However, they can be of use to the network participants and the Commission, to get more insight into the individual contributions.

Participant Number 1 : INFN.LNF Laboratori Nazionali di Frascati

The work reported this year comes from participants from INFN in Frascati, Rome, Naples, Parma, Pavia, Perugia and Torino. As the data from DAΦNE will arrive, beginning from summer 1999 as presently envisaged, the other INFN groups plan to become active, and contribute to the current work. We shall report here the contribution from each of the groups named above.

• • The experimental groups from **Frascati** and **Rome** contributing to this network, report the successful installation of the KLOE detector in the DAΦNE interaction region since beginning of 1999. The first three months of the year have been dedicated to detector calibration with cosmic rays. DAΦNE started to provide e^+e^- collisons on April 14th 1999.

• • As for the theoretical activity, in the following we list the contributions from various participants.

• In 1998-1999 the research activity of Gino Isidori, from **Frascati**, and G. D'Ambrosio from **Naples** has been focused on rare K decays, both within and beyond the Standard Model.

Together with G. Ecker and J. Portolés, G. Isidori and G. D'Ambrosio have performed a model-independent analysis of $K^+ \to \pi^+\ell^+\ell^-$ and $K_S \to \pi^0\ell^+\ell^-$ decays, including $K \to 3\pi$ unitarity corrections and a general decomposition of the dispersive amplitude. As a result, they have been able to improve the description of the existing $K^+ \to \pi^+e^+e^-$ data and to to predict with good accuracy the ratio $B(K^+ \to \pi^+\mu^+\mu^-)/B(K^+ \to \pi^+e^+e^-)$. Through this collaboration of the nodes Valencia-Vienna-Frascati-Naples, we have now a better understanding of weak matrix elements and the relative role of unitarity corrections and local contributions in non-leptonic Kaon decays.

• A significant result has been obtained by G. Isidori, together with G. Colangelo, in the study rare decays beyond the Standard Model. Contrary to previous analyses, it has been shown that the branching ratios of $K \to \pi\nu\bar{\nu}$ and $K_L \to \pi^0 e^+e^-$ decays could be substantially increased in specific supersymmetric extensions of the Standard Model. Interestingly, the upper bounds obtained in this scenario for $B(K_L \to \pi^0\nu\bar{\nu})$ are not far from the expected KLOE sensitivity.

• A detailed analysis of the CP conserving contribution to $K_L \to \pi^0\nu\bar{\nu}$ has been carried out by G. Isidori together with G. Buchalla. They have shown that, although sensitive in part to nonperturbative physics, this contribution is rather well under control and turns out to be negligible. This enforces the role of the $K_L \to \pi^0\nu\bar{\nu}$ in probing CP violation and short-distance dynamics.

• G. Pancheri from **Frascati** has been involved in the study of the hadronic contribution to $(g-2)_\mu$ via the hadronic e^+e^- cross-section, through the partial supervision of the PhD thesis by S. Spagnolo from the KLOE collaboration on the measurement of the hadronic cross-section at DAΦNE using Initial State Bremsstrahlung to tune the energy of the hadronic system. This work is part of the network effort, carried on mostly by the ZEUTHEN-Karlsruhe group, to prepare all the theoretical and experimental work for reduction of the errror on $\alpha_{QED}(M_Z)$ and $(g-2)_\mu$.

G. Pancheri has represented the network giving invited talks on DAΦNE physics at the Zeuthen Workshop on *Loops and Legs in Gauge Theories*, April 1998 in Rheinsberg, at the *Workshop on Photon Interactions and the Photon Structure*, Lund September 1998 and at the *Winter Meeting on Fundamental Interactions*, Sierra Nevada in February 1999.

• The Frascati group has organized the LNF Spring School 1998, held together with the VII the EURODAPHNE collaboration Meeting, and the Radiative Correction Workshop in October 1998.

• O. Panella and Y. N. Srivastava of the **Perugia** group have continued the study of Lepton Number Violating processes both at high energy (pp reactions) and low energy (neutrinoless double beta decay). A comparative study of the potential of low- vs. high-energy facilities with respect to constraining the parameters of compositeness effective lagrangians has been performed.

Paolo Gensini has continued in the analysis of the quality of presently available information on low–energy meson–baryon interactions in the S = -1 sector: preliminary results on the information to be gained for the experimentally inaccessible πY channels tthrough the use of analytic continuation techniques have been presented in September 1998 at the International Conference "Baryons '98" in Bonn.

• According to the research program, the **Pavia** group, contributing to the item "Radiative Corrections at DAΦNE", considered the problem of computing QED radiative corrections to the Large-Angle Bhabha scattering cross section.

The relevance of the item within the DAΦNE physics program is connected to the precise determination of the machine luminosity, that has to be known at better than 1%. QED corrections have been computed in the framework of the Parton Shower Method, which has been implemented in a Monte Carlo generator (BABAYAGA) suitable for data analysis. At present, the generator takes into account all-order leading logarithmic (LL) corrections, plus part of the next-to-leading ones via a suitable adjustment of the maximum virtuality of the emitting fermions. It can generate an arbitrary number of photons. In order to test the reliability of the approach, a benchmark calculation, including exact $O(\alpha)$

corrections and higher order LL contributions, has been developed and implemented in a Monte Carlo integrator (LABSPV). From a comparison between BABAYAGA and LABSPV, one can conclude that the present theoretical accuracy of BABAYAGA is at the level of 0.5%. Work is in progress towards merging the perturbative results in the LL algorithm. BABAYAGA/LABSPV are distributed to the interested experimental collaborations.

• L. Trentadue of the **Parma** group has further pursued the goal of determining the large angle Bhabha cross section with and accuracy of the 0.1%. A Monte Carlo Program (NLLBHA-Large Angle) has been developed. The present accuracy is below 0.3% and work to improve it is continuing. The program has been made available to the DAPHNE experimental groups. The single photon physics to determine the total hadronic cross-section has been studied by including radiative correction effects.

• The research activity of the **Torino** group has been centered on Hypernuclear Physics. The decay widths of various Λ-hypernuclei hve been evaluated in the different channels $\Lambda \to \pi N$, $\Lambda N \to NN$, $\Lambda NN \to NNN$, by employing the Green's function method in the local density approximation. For the first time the available experimental data over the whole medium-heavy nuclear mass spectrum (from ${}^{12}_{\Lambda}$C to ${}^{208}_{\Lambda}$Pb) have been reproduced within a consistent theoretical framework.

As a further step toward consistency in the many-body approach, A microscopic evaluation of the three-body decay widths ($\Lambda NN \to NNN$), which were previously incorporated in a purely phenomenological way, has been started. Preliminary results seem to be consistent with previous calculations and point to new, interesting features of Λ-hypernuclei decays.

Report from Gudrun Hiller, TMR post-doc, from October 1998 to May 1999

After my arrival at the LNF in Frascati in October 1998 I continued to work on the possibility of the extraction of the CKM matrix elements $|V_{td}/V_{ts}|$ from inclusive semileptonic B-decays $B- > X_{d,s}l^+l^-$ together with Ahmed Ali (DESY). The paper 'A theoretical reappraisal of branching ratios and CP asymmetries in the decays $B- > (X_d, X_s)l^+l^-$ and determination of CKM parameters' , hep-ph/9812267, LNF-98/041(98), DESY 98-187, has now been accepted by the European Journal of Physics (ex Zeitschrift fuer Physik) C for publication.

With Gino Isidori (LNF) I started to work on Kaon physics, namely the radiative decay $K- > \mu\nu\gamma$. The transversal lepton polarization p_T is an interesting observable, as it vanishes in the Standard model at tree level. We have estimated for the first time the dominant Standard model background to p_T due to π^0 rescattering, which is very useful to identify possible new physics contribution. A measurement of this observable is beeing done now at KEK and results are expected to be presented at the Kaon99 conference. We further gave an outlook into an upper bound of minimal SUSY effects with unbroken R-parity. The paper, 'The CP-conserving contribution to the transverse muon polarization in $K- > \mu\nu\gamma$' hep-ph/9903284, LNF-99/007(p) has been accepted for publication in Physics Letters B. I presented this work in a talk at the Frascati Springschool/Eurodaphne collaboration meeting '99 on 17.4.1999.

At present I am studying exclusive rare $B- > (K, K^*)l^+l^-$ decays. I am doing a phenomenological analysis of the decay spectra, asymmetries in the first step in the standard model and later in minimal supersymmetric extensions. This is necessary as has been pointed out at the first LHCB meeting on 15th of January 1999 at Cern, which I have participated. This recent project is done in collaboration with Ahmed Ali, L.T.Handoko (DESY) and Patricia Ball (CERN).

Personnel in INFN.LNF node

The total number of researchers working on network related activities this year has been 15 staff members and 3 PhD students. In this total, the doctoral students working with the experimental groups and whose activity will contribute to the network success through the data analysis, have not been included.

Staff members

S. Bellucci, Frascati. 12 months. 100%
J. Lee-Franzini, Frascati. 12 months. 100%
G. Isidori, Frascati. 12 months,100%
G. Hiller, TMR fellow, Frascati. 6 months, 100%
G. Pancheri, Frascati. 12 months, 100%
P. Franzini, U. of Rome, 12 months, 100%.
G. D'Ambrosio, INFN Naples. 12 months, 100%
W. Alberico, U. of Torino, 2 mo, 100%
G. Montagna, O. Nicrosini, F. Piccinini, INFN Pavia, 6 months total
L. Trentadue, U. of Parma, 3mo, 100%
P. Gensini(6mo), O. Panella (3mo), Y. Srivastava (3mo), U. of Perugia, 12 mo total

Ph. D. Students

C. Carloni Calame,INFN and U. of Pavia
C. Lunardini, SISSA and INFN Trieste
Gianni Garbarino from INFN and U. of Torino

Administrative Assistant

A. Mantella, from INFN Frascati, 12 month 75 %

Travel Expenditures

1. R. Dalitz from Oxford (U.K. node) travel to Frascati in April 1998,
2. G. Pancheri to Paris June 1998 for meeting with A. Courau and Paris node,
3. C. Colangelo to Bern node in June 1998 for Workshop on K_{l4}-decays.
4. G. D'Ambrosio, G. Isidori, A. Mantella and G. Pancheri to the VIII the EURODAPHNE collaboration Meeting in Paris, October 1998.
5. G. Isidori to Valencia node in November
6. G. D'Ambrosio for Workshop in Bad Honnef and meeting with participants from other nodes in November 1998,

7. G. Pancheri to Lund in September 1998 for talk on *Photon Physics at DAΦNE* ,
8. G. Pancheri to Rutherford Laboratory in December 1999.

All the above costs were born by the Contract.

List of Publications from the INFN node

G. Pancheri *Physics at DAΦNE* , Acta Physica Pol. **B29** (1998) 2763.

G. Pancheri *Photons and Other Physics at DAΦNE* , Proceedings of Workshop on Photon Interactions and the Photon Structure, Lund, 10-12 September 1998, eds. G. Jarlskog and T. Sjostrand.

G. Buchalla and G. Isidori, *The CP conserving contribution to* $K \to \pi^0 \nu\bar{\nu}$ *in the Standard Model*, Phys. Lett. B440, 170 (1998).

G. D'Ambrosio, G. Ecker, G. Isidori and J. Portolés, *The decays* $K \to \pi\ell^+\ell^-$ *beyond leading order in the chiral expansion*, J. High Energy Phys. 08, 004 (1998).

G. Colangelo and G. Isidori, *Supersymmetric contributions to rare kaon decays: beyond the single mass insertion approximation*, J. High Energy Phys. 09, 009 (1998).

G. Isidori, *Precision tests and searches for new physics with K decays*, invited talk at the International Workshop on CP Violation in K, Tokyo, Japan, 18-19 Dec 1998 (hep-ph/9902235), to appear in the Proceedings.

A. Ali and G. Hiller, *A theoretical reappraisal of branching ratios and CP asymmetries in the decays* $B \to (X_d, X_s)\ell^+\ell^-$ *and determination of the CKM parameters.* DESY-98-187, LNF-98/041(P), December 1998, hep-ph/9812267, accepted for publication in Eur.Phys.J.C.

G.Hiller and G. Isidori, *The CP-conserving contribution to the transverse muon polarization in* $K^+ \to \mu^+\nu\gamma$, LNF-99/007(P), March 1999, hep-ph/9903284, accepted for publication in Phys. Lett. B.

G .D'Ambrosio, G. Ecker, G. Isidori and J. Portolés, *The decays* $K \to \pi l^+ l^-$ *beyond the leading order in the chiral expansion*, JHEP **08** (1998) 004, hep-ph/9808289.

G. D'Ambrosio, Contribution to the workshop *The Physics of Strangeness* , organized by M.J.Savage and R. Springer, INT ,Seattle (Univ. of Washington) 1998.

G. D'Ambrosio, Contribution to the meeting *Chiral Effective Theories*, organized by J. Bijnens and U.G.Meissner, Bad Honnef, Germany, 30 Nov.-4 Dec 1998, hep-ph/9901381.

O. Panella, C. Carimalo and Y.N. Srivastava, *Production of Like Sign Dileptons in pp Collisions through Composite Majorana Neutrinos.*, INFN/TH-99/01 hep-ph/9903253, Submitted to Physical Review D.

P. Gensini, R. Hurtado and G. Violini, *What Do We Know About Low–Energy* $\bar{K}N$ *Interactions? Need and Possibilities of New Experiments at DAΦNE Genshikaku Kenkyuu* **48**, N. 4 (1998) 51–56 (E-print No. nucl-th/9804024).

P. Gensini, R. Hurtado and G. Violini *Dispersion Relations in* $\bar{K}N - \pi Y$ *Coupled Channel Analyses* Università di Perugia report 3 November 1998, pres. at *"Baryons '98"*, Bonn, September 1998, to be publ. in the Proceedings (E-print No. nucl-th/9811010)

C.M. Carloni Calame, C. Lunardini, G. Montagna, O. Nicrosini and F. Piccinini, *Large-Angle Bhabha Scattering and Luminosity at Low Energy e^+e^- Machines*, FNT/T-99/07, in press on Proceedings Supplements Nuclear Physics **B**.

A.B. Arbuzov, E.A. Kuraev , N.P.Merenkov, L. Trentadue, *Hadronic Cross-sections in electron-positron annihilation with tagged photon* JHEP 9812:009,1998

W. M. Alberico, A. De Pace, G, Garbarino and A. Ramos, *Weak decays of medium and heavy Λ-hypernuclei*, nucl-th/9902023, submitted to Phys. Rev.

W. M. Alberico, A. De Pace, G, Garbarino and A. Ramos, *Decay rates of medium-heavy Λ-hypernuclei within the Propagator Method*, proceeding of the APCTP Workshop on *Strangeness Nuclear Physics*, Seoul, Feb. 19-22, 1999

Participant Number 2 : CRLC.RAL Rutherford Appleton Laboratory

The work of the UK node during the first year has been primarily concerned with the nature of the scalar mesons, their place in the spectrum of hadrons and their relation to the structure of QCD. Studies have concentrated on their relative production mechanisms in high energy central collisions, in J/ψ decays and in two photon reactions. The aim is to bring an understanding of how such states will appear in radiative decays of the ϕ to be studied with the KLOE detector at DAPHNE and how the analysis of the these decays will add to our total picture of light hadron spectroscopy. The second line of attack has been using QCD sum-rules. This provides a way of connecting low energy hadron physics, which is governed by the non-perturbative aspects of QCD (in particular confinement), with the more readily computed consequences of perturbative QCD at higher energies. An exploration of both Borel and finite energy sum-rules are under way for the scalar currents with different quark and gluonic compositions. To what exact these sum-rules are saturated by the known scalar mesons, the need for instanton contributions and their detailed modelling is the subject of current investigation.

In order to understand the nature of the enigmatic mesons in the region below 2 Gev accessible to DAFNE, studies have been made of their production in the central region of $pp \to pp + meson$ and in $e^+e^- \to e^+e^- + meson$. These studies have concentrated on the azimuthal angular dependence. The idea is to compare that in the e^+e^-, where the production mechanism is controlled, with the pp process. It has been found that the production of well known $q\bar{q}$ mesons in pp reveal that the Pomeron, production process, transforms as if a non-conserved vector current. This now opens the possibility to make more controlled studies of scalar meson production, in particular the enigmatic $f_0(980)$, and complement the studies to be made at DAFNE. The studies of the production of low mass pion pairs in pp and at DAFNE is also in process.

Personnel in U.K. node

1. F.E. Close, Rutherford Appleton Laboratory. 10%
2. G. Gounaris et al., University of Thessaloniki.
3. R.H. Dalitz, University of Oxford. 12months. 25%
4. A. Donnachie, U. of Manchester, 12 months, 25%.
5. M.R. Pennington, University of Durham. 12 months 60%
6. S.N. Cherry, University of Durham. 12 months 100%
7. K. Benhaddou, University of Durham. 6 months 100%

Travel paid by Durham

1. VIIth EuroDAPHNE Collaboration meeting, Frascati, April 1998, M.R. Pennington.
2. DAPHNE K_{e4} working group meeting, Bern, June 1998, M.R. Pennington.

3. Workshop on photon interactions and photon structure, Lund, September 1998, M.R. Pennington.

4. VIIIth EuroDAPHNE Collaboration meeting, Paris, October 1998, R.H. Dalitz (Oxford) and M.R. Pennington.

5. WHS99 — Workshop on Hadron Spectroscopy, Frascati, March 1999, M.R. Pennington.

Personnel supported by the network

1. Kamel Benhaddou, French, date of birth 20th November 1973, Ph.D. student from October 1st 1998.

Relevant publications by the UK node

1. F E Close and G Schuler, *Central production of mesons: Exotic states versus pomeron structure*, hep-ph/9902243, Physics Letters (in press)

2. F E Close and G Schuler, *Evidence that the pomeron transforms as a nonconserved vector current*, hep-ph/9905305

3. A. Donnachie and Y. Kalashnikova, *Hunting the Vector Hybrid*, hep-ph9901334 , submitted to Phys. Rev. D

4. M.E. Boglione and M.R. Pennington, *Determination of Radiative Widths of Scalar Mesons from Experimental Results on $\gamma\gamma \to \pi\pi$*, Eur. Jour. of Phys. (in press)

5. M.R. Pennington, *Glueballs: the naked truth*,

   Proc. Workshop on Photon Interactions and Photon Structure, Lund, Sweden,

   Sept. 1998 (ed. G. Jarlskog and T. Sjostrand; pub. Lund, 1999) pp. 313-328.

6. M.R. Pennington, *Roy equations: their history and use*,

   VIII EuroDAPHNE Collaboration meeting, Paris, Oct. 1998, (ed. J. Stern; pub. IN2P3 et Universite Pierre et Marie Curie) pp. 1-20.

7. M.R. Pennington, *Riddle of the scalars: where is the σ?*

   Proc. Workshop on Hadron Spectroscopy, Frascati, Italy, March 1999 (ed. T. Bressani et al.) (in press).

Participant Number 3 : CNRS.IN2.IPN Orsay, Paris

During the last year, the research effort and results obtained within the Orsay-Paris node mainly concern the following five subjects:

1. Chiral sum rules and determination of low-energy effective constants

a) Effective description of electromagnetic corrections to Goldstone boson interactions at low energy necessitates an evaluation of chiral sum rules in the chiral limit. It is shown how available experimental information on $(VV - AA)$ spectral functions can be extrapolated to the chiral limit, allowing a precise determination of the leading electromagnetic low-energy constants, [1, 2].

b) A combined use of χPT and finite-energy QCD sum rules is proposed in order to control systematically both quark mass and high energy corrections. The method is applied to a precise determination of L_{10}, using the recent data on $(VV - AA)$ spectral functions obtained by the ALEPH collaboration from hadronic τ-decays. The relevant chiral order parameter of dimension 6 is found to exceed by a factor ~ 3 the value given by the vacuum saturation assumption [5].

c) Sum rules for OZI violating two-point funtion $\langle(\bar{u}u + \bar{d}d)\bar{s}s\rangle$ are investigated for $m_{\mathrm{u}} = m_{\mathrm{d}} = 0$ and $m_{\mathrm{s}} \neq 0$ but small. Using the information on quasi-two-body scattering $(\pi\pi, K\bar{K} \to \pi\pi, K\bar{K})$ in the $(0 - 2$ GeV) region, an important OZI rule violating effect is found, leading to a substantial variation of $\langle\bar{u}u + \bar{d}d\rangle$ condensate when the number N_f of massless flavours varies from $N_f = 2$ to $N_f = 3$ [6].

2. Experimental tests of the mechanism of chiral symmetry breaking

a) Connection between the violation of the GOR relation and the low-energy $\pi\pi$ scattering amplitude is reconsidered within the $N_f = 2$ $G\chi$PT [7], thereby avoiding the potential problem of (possibly large) OZI violation in the 0^{++} channel, which could be present in the $N_f = 3$ case.

b) The possibility to extract experimental information on $q\bar{q}$-condensate from azimuthal asymmetries in the decays $\tau \to 3\pi + \nu_\tau$ is investigated. Explicit one-loop, $N_f = 2$ GχPT calculation shows that, close to threshold, these asymmetries are large and particularly sensitive to $\langle\bar{q}q\rangle$. Future high luminosity B-factories (and/or τ-charm factories) should have enough $\tau \to 3\pi + \nu_\tau$ events in the threshold region to provide a sensitive test of the GOR relation, offering an independent cross check of the test based on $\pi\pi$ scattering (DAΦNE, DIRAC, ...) [8].

3. $\gamma\gamma$ reactions with KLOE detector at DAΦNE

The feasibility of two photon reaction experiments at DAΦNE with the KLOE detector excluding the small angle tagging system is reexamined. Event-rate predictions of interesting channel $\gamma\gamma \to \pi^0, \eta$ and $\gamma\gamma \to \pi\pi$ are discussed [9].

4. Connection with B-physics

a) The connection between the constant F_B and light quark condensate is investigated using the complete set of rapidly converging heavy-light chiral sum rules [10].

b) New CP-violating observables in the (sequential) decays $B \to$ hyperon + antihyperon are proposed. They allow to resolve some discrete ambiguities in the CP angles of the unitarity triangle [11, 12].

c) Form factors of heavy-to-light semi-leptonic transitions, $B \to \pi$, $B \to \rho \ldots$ are investigated in the limit of large initial hadron mass and a large final hadron energy. Information on q^2-dependence of these form factors is obtained using the light-cone QCD sum rules [13].

5. Theoretical investigation of chiral symmetry breaking in vector-like gauge theories

a) The mechanism of chiral symmetry breaking is shown to be related to the average properties of the infrared spectrum of the Euclidean Dirac operator in the large volume limit. It is suggested that as N_f increases, the theory first meets a phase transition in which $\langle \bar{q}q \rangle = 0$ but the χS is still broken due to $F_\pi^2 \neq 0$. For still larger N_f, χS is finally restored. Below but close to the first phase transition point, it is natural to expect a small value of $\langle \bar{q}q \rangle$, which should then be rather sensitive to N_f. A failure of OZI rule and of the large N_c approximation due to large fluctuation of small Dirac eigenvalues should then be expected for chiral order parameters [15, 16].

b) The Leutwyler-Smilga sum rules for the inverse moments of Dirac eigenvalues are generalized to the case of a small $\bar{q}q$ condensate. It is shown that the (large) volume dependence of LS sum rules is particularly sensitive to the size of $\langle \bar{q}q \rangle$. New numerical tests on a lattice of finite size, free of problems with doublers are proposed [16].

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[1] B. Moussallam, "Reanalysis of the Das et al. sum rule and application to the chiral $\mathcal{O}(p^4)$ parameters", Eur. Phys. Jour. **C6** (1999) 681.

[2] B. Moussallam, "An estimate of the $\mathcal{O}(p^4)$ E.M. contribution to the $M_{\pi^+} - M_{\pi^0}$", see also [3] and [4].

[3] "Proceedings of the VIII Eurodaphne Collaboration Meeting", LPNHE, Paris, 19-21 October 1998.

[4] "Miniproceedings of the meeting on Chiral Effective Theories", WE-Heraus-Seminar, Bad Honnef (Germany) Nov. 30 - Dec. 4 1998, hep-ph/9901381.

[5] M. Davier, L. Girlanda, A. Höcker and J. Stern, "Finite energy chiral sum rules and τ spectral functions", Phys. Rev. D **58** (1998) 096014.

[6] B. Moussallam, "Flavour dependence of the quark condensate", work in progress.

[7] L. Girlanda, "Relation between quark condensate and π–π scattering in two-flavours GχPT", in [3] and to be published.

[8] L. Girlanda and J. Stern, "The decay $\tau \to 3\pi + \nu_\tau$ in Generalized Chiral Perturbation Theory", in preparation (see also the contribution by L. Girlanda in [4]).

[9] S. Ong, "Two-photon reactions with KLOE detector at DaΦne", hep-ex/9902030, to be published.

[10] S. Descotes-Genon, "Heavy-light chiral sum rules", in [3] and to be published.

[11] J. Charles, "CP-violation in B-decays: the problem of the determination of α", in [3].

[12] J. Charles, A. Le Yaouanc, L. Oliver, O. Pene, J.C. Raynal, "New CP observables in $B^0(t) \to$ hyperon + antihyperon from parity violation in the sequential decay", Phys. Rev. D **58** (1998) 114021.

[13] J. Charles, A. Le Yaouanc, L. Oliver, O. Pene, J.C. Raynal, "Heavy to light form factors in the final hadron large energy limit of QCD", to appear in Phys. Rev. D; "Heavy to light form factors in the final hadron large energy limit: covariant quark model approach", Phys. Lett. **B451** (1999) 187.

[14] J. Stern, "Light quark masses and condensates in QCD", in "Chiral Dynamics: Theory and Experiment", eds. A.M. Bernstein, D. Drechsel and T. Walcher, Springer-Verlag 1998, Lecture Notes in Physics 513.

[15] J. Stern, "Two alternatives of spontaneous chiral symmetry breaking in QCD", hep-ph/9801282;
"QCD inequalities and the renormalized quark condensate", in [3];
"Theoretical study of chiral symmetry breaking in QCD: recent development", in [4] and work in preparation.

[16] S. Descotes-Genon and J. Stern, "Leutwyler-Smilga sum rules in Generalized Chiral Perturbation Theory", to be published.

Participant Number 4 : CNRS.CPTH Marseille-Luminy

Coordinator: Eduardo de RAFAEL

1. Brief description of the main research progress.
The activities of the CPT–Marseille node have been centered on the following topics:

a) Large–N_c QCD and applications to weak K–matrix elements.

b) Electromagnetic corrections to $\pi - \pi$ scattering and K–semileptonic decays.

c) Lattice QCD determination of B–factors for K–weak matrix elements.

Concerning topic **a)**, we have succeeded to obtain an analytic evaluation of the B factors $B_7^{(1/2)}$ and $B_7^{(3/2)}$ to first non–trivial order in the chiral expansion and in the $1/N_c$ expansion [3]. This is a first step towards the final goal of getting the full $\Delta S = 1$ and $\Delta S = 2$ amplitudes in K–decays and a controlled analytic evaluation of ϵ'/ϵ in the Standard Model, independent of the lattice QCD evaluations.

Results concerning topic **b)** have been obtained within the framework of χPT and have been published in [4]. It has been shown in this analysis that virtual electromagnetic effects are comparable in size to chiral two loop effects and must, therefore, be taken into account in future phenomenological analyses.

On topic **c)**, preliminary results have been published in the proceedings of *Lattice 98* [7]. These include lattice estimates of B_K, $B_7^{(3/2)}$ and $B_8^{(3/2)}$. They are obtained using a mean-field-improved, Sheikholeslami-Wohlert fermion action. They are currently being finalized and will be the subject of a forthcoming paper.

Our efforts at present are concentrated on the following questions:

- Scalar and heavy pseudoscalar mesons in large–N_c and constraints in their spectrum from the OPE short–distance behaviour of QCD Green's functions. (M. Knecht and E. de Rafael in collaboration with S. Peris and A. Pich.) This is a necessary step in order to pursue the program of topic **a)** above.

- Evaluation of the couplings of the low–energy effective Lagrangian which govern the electromagnetic corrections to $K-$ semileptonic processes. (Work in progress by M. Knecht, S. Peris, M. Perrottet and E. de Rafael which is, in particular, necessary to complete previous work by M. Knecht, H. Neufeld, H. Rupertsberger and P. Talavera.)

- Work in progress by M. Knecht, (in collaboration with L. Ametller and P. Talavera) on the process $\gamma + \gamma \to 3\pi$.

- Work by E. de Rafael with Boris Phily, a graduate student at the CPT, on "Tests of Large–N_c QCD from Hadronic τ–Decays".

- Finalizing the results of **c)** (L. Lellouch and collaborators).

- Determinations of the matrix elements for $K^0 - \bar{K}^0$-mixing in supersymmetric extensions of the standard model (L. Lellouch and collaborators).

- New methods in lattice QCD to determine the size of the quark condensate and to investigate the mechanism of chiral symmetry breaking (L. Lellouch and collaborators).

- Work by P. Chiappetta and collaborators on possible new phenomenological constraints on supersymmetric extensions of the Standard Model from CP–violation in K–Physics.

2. List of publications.
See the references below.

3. Post-docs employed.
The Marseille node does not have a Eurodaphne post-doc this year.

4. List of participants and percentage of time spent.

Pierre CHIAPPETTA	*2 m/y*
Marc KNECHT	*9 m/y*
Laurent LELLOUCH	*4 m/y*
Michel PERROTTET	*9 m/y*
Eduardo de RAFAEL	*9 m/y*

5. Travel Expenditures born by the Contract. VII-th Eurodaphne collaboration meeting, Frascati, April 1998 (M. Perrottet). Kl4 workshop in Bern, June 1998 (M. Knecht). Visit of H. Neufeld from the Vienna node to Marseilles, September 1998. Visit of J. I. Latorre from the Barcelona node to Marseilles, October 1998. VIII-th Eurodaphne collaboration meeting, Paris, October 1998 (M. Knecht, L. Lelleouch, M. Perrottet, E. de Rafael). Workshop on chiral effective theories, Bad-Honnef, December 1998 (M. Knecht, E. de Rafael).

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[1] S. Peris, M. Perrottet and E. de Rafael, *Matching Long and Short Distances in Large-N_c QCD*, JHEP **05** (1998) 011.

[2] M. Knecht and E. de Rafael, *Patterns of spontaneous chiral symmetry breaking in the large–N_c limit of QCD–like theories,* Phys. Lett. **B424** (1998) 335.

[3] M. Knecht, S. Peris and E. de Rafael, *Matrix Elements of Electroweak Penguin Operators in the $1/N_c$ Expansion,* hep-ph/9812471 (to appear in Phys. Lett. **B**)

[4] M. Knecht and R. Urech, *Virtual Photons in Low Energy $\pi - \pi$ Scattering*, Nucl. Phys. **B519** (1998) 329.

[5] E. de Rafael, *Large–N_c QCD and Spontaneous Chiral Symmetry Breaking*, hep-ph/9811491 (to be published in the Proceedings of the QCD 98 Conference at Montpellier, France.)

[6] E. de Rafael, *Chiral Sum Rules*, (to be published in the Proceedings of the TAU 98 Conference in Santander, Spain.)

[7] L. Lellouch and C.J. Lin (UKQCD Collaboration), CERN-TH/98-307, CPT-98/PE.3690, hep-lat/9809142, in proceedings of *Lattice 98: 16th International Symposium on Lattice Field Theory*, Boulder, CO, USA, 13-18 july 1998.

In addition L.Lelouch had been invited to present, amongst other things, the lattice results for B_K at The XXXIVth Rencontres de Moriond ELECTROWEAK INTERACTIONS AND UNIFIED THEORIES Les Arcs 1800, March 13–20, 1999 and these results will appear in the proceedings. The title of the talk was
"$\Delta m_s/\Delta m_d$ and ϵ_K in quenched QCD ".

Participant N.5. : UABCN.DF Universitat Autònoma de Barcelona

Models linking Chiral Perturbation Theory (ChPT) with Quantum Chromodynamics (QCD) and, more specifically, with the large N_c-limit of QCD have been explored. Interesting results on e.m. pion mass differences and weak matrix elements have been obtained. Most of this work appears as joint publications of the Barcelona and Marseilles nodes.

The related issue of the ninth (singlet) pseudoscalar meson has been similarly analysed and results have been obtained on the classical subject of eta-eta' mixing. One confirms recent results pointing to a mixing angle somewhat less negative (- 17 degrees) than the standard one (- 19.5 degrees). More recent discussions suggest a more complicated, two-angle description for the eta-eta' complex; again some results of interest have been derived. The DAPHNE machine is particularly suitable for the corresponding experimental tests in a recent future. The same happens with eta and eta' decay modes which have also been analized by the Barcelona node.

The progress in vector meson physics and vector meson dominance has been less active and fruitful. Attempts to fine-tune vector meson properties to a few per cent level are in progress, look rather interesting and are expected to be finished quite soon (Barcelona, Granada, Frascati nodes with Brussels).

Nuclear physics items, on the other hand, have been studied to a great extension and with clear success. Nuclear physicists from the Barcelona and Valencia nodes, which had already some collaboration between them before joining the Eurodaphne network, are now strongly collaborating. Many papers on hyperon properties and decays have been written and, again, DAPHNE is expected to cover the experimental counterpart of these results enlarging the collaboration with the Frascati node.

Some effort has also been devoted in Barcelona to discuss the foundations of quantum mechanics. DAPHNE will provide neutral kaon pairs which are entangled and could allow for experimental research on the Einstein-Podolsky-Rosen (EPR) paradox. Previous analyses were rather negative on this issue; our results are more optimistic: EPR-correlations and Bell-inequalities are in principle testable at DAPHNE.

References

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[3] B. Ancochea, A. Bramon and M. Nowakowski, "Bell inequalities for K0 anti-K0 pairs from phi resonance decays," hep-ph/9811404.

[4] J. Bijnens, E. Pallante and J. Prades, "Obtaining K $\rightarrow$ pi pi from off-shell K $\rightarrow$ pi amplitudes," Nucl. Phys. **B521**, 305 (1998) hep-ph/9801326.

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[15] J.C. Nacher, E. Oset, H. Toki and A. Ramos, "Radiative production of the Lambda(1405) resonance in K- collisions on protons and nuclei," nucl-th/9902071.

[16] E. Oset, J.A. Oller, J.R. Pelaez and A. Ramos, "Meson-meson and meson - baryon interactions in a chiral nonperturbative approach," Acta Phys. Polon. **B29**, 3101 (1998) hep-ph/9806460.

[17] E. Oset and A. Ramos, "Weak decay of Lambda hypernuclei," Prog. Part. Nucl. Phys. **41**, 191 (1998) nucl-th/9807018.

[18] E. Oset and A. Ramos, "Non perturbative chiral approach to s-wave anti-K N interactions," Nucl. Phys. **A635**, 99 (1998).

[19] E. Oset *et al.*, "Recent progress on the chiral unitary approach to meson-meson and meson baryon interactions," nucl-th/9902001.

[20] A. Parreno, A. Ramos, N.G. Kelkar and C. Bennhold, "The n p $\rightarrow$ Lambda p reaction within a one meson exchange model," nucl-th/9809053.

[21] A. Parreno, A. Ramos, N.G. Kelkar and C. Bennhold, "The weak strangeness production reaction p n $\rightarrow$ p Lambda in a one boson exchange model," nucl-th/9810020.

[22] A. Parreno, A. Ramos, C. Bennhold and K. Maltman, "Violation of the Delta(I) = 1/2 rule in the nonmesonic weak decay of hypernuclei," Phys. Lett. **B435**, 1 (1998).

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[24] S. Peris, M. Perrottet and E. de Rafael, "Matching long and short distances in large N(c) QCD," JHEP **05**, 011 (1998) hep-ph/9805442.

[25] A. Pich and J. Prades, "Perturbative quark mass corrections to the tau hadronic width," JHEP **06**, 013 (1998) hep-ph/9804462.

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[27] A. Ramos and E. Oset, "anti-K N interaction and kaons in the nuclear medium," nucl-th/9810014.

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[29] I. Vidana, A. Polls, A. Ramos and M. Hjorth-Jensen, "Hyperon properties in finite nuclei using realistic Y N interactions," Nucl. Phys. **A644**, 201 (1998) nucl-th/9805032.

[30] I. Vidana, A. Polls, A. Ramos and M. Hjorth-Jensen, "Binding energy of Lambda hypernuclei from realistic Y N interactions," nucl-th/9809060.

Young postdoc

Jerome Charles will start his Eurodaphne postdoc in Barcelona next Fall.

Participants (months)

Barcelona UAB and UB: A. Bramon (12), Ll. Ametller (12), E. Bagan (6), S. Peris (12), R. Escribano (12), R. Munoz (6); P.Pascual (6), R. Tarrach (6), D. Espriu (6), J.I. Latorre (6), J. Taron (12), P. Herrera (12), A. Ramos (12), A. Parreno (12).
Granada, subcontractor: F. Cornet(6), A. Grau (12), J. Prades (12).

Travel Expenditures born by the Contract

- VIIth Eurodaphne Collaboration Meeting, Frascati, April 1998:

  A. Grau and R. Escribano

- VIIth Eurodaphne Colaboration Meeting, Paris, October 1998: L. Ametller, A. Bramon, F. Cornet, R. Escribano, S. Peris and J. Taron.

- Visit to University of Bern: J. Prades, Nov.Dec. 1998.

- Attendance of Trento meeting (1998): A. Ramos.

Participant N.6 : UVAL.IFC.DFT University of Valencia

- **Rare kaon decays.-** The long–distance contribution to the decay $K_L \to \mu^+\mu^-$ has been investigated, using chiral lagrangians and $1/N_C$ arguments. It has been shown that this contribution can be rigorously calculated in the large–N_C limit, allowing to derive useful constraints (information on the top mass and quark mixing factors) on the short–distance contribution from the experimental data.

  The contributions coming from intermediate vector mesons in kaon decays have been investigated. In particular, a detailed analysis of the decays $K_L \to \pi^+\pi^-\gamma$ and $K \to \pi\ell^+\ell^-$ has been performed.

- **Strange quark mass.-** A detailed calculation of strange quark mass corrections to the hadronic tau decay width has been performed. From the Cabibbo–suppressed decays it is then possible to determine the value of m_s. A preliminary value has been already obtained. The final determination, using the most recent ALEPH data will be published soon. The numerical value of m_s is very important in order to calculate ϵ'/ϵ.

- **Effective Lagrangians in the resonance region.-** We have initiated a research program aiming to extend the validity range of Chiral Perturbation Theory to the resonance region, by incorporating explicit matter fields in the effective Lagrangian. Encouraging results have been already obtained for the pion form factor. A detailed study of the scalar form factor will be made in the next six months.

- **Unitarization effects in hadronic processes.-** Unitarization techniques have been developed in order to include the large effect of final–state interactions to all orders in the chiral expansion. This provides a resummation of the chiral logarithms, which is quite important in the scalar sector. Meson–meson, meson–baryon, and photon–photon processes, and radiative phi decays have been investigated.

- **Hypernuclei.-** Predictions have been made for the K-N interaction with all coupled channels and calculations for K-deuteron, to be measured at DAPHNE are now in progress. Similarly, a many body theory for K- nucleus interaction has been done and agreement with present data of K- atoms found excellent. At the same time predictions are made of deeply bound kaonic atoms , never observed , and that could be eventually measured at DAPHNE. Such measurements would bring relevant information to answer important questions like whether there are Kaon condensates or not in neutron stars. A comprehensive review on Hypernuclei Decay which could serve as a guideline for the experiments planned at FINUDA has been written.

- **Effective Field Theories.-** An extensive set of lecture notes on Effective Field Theories have beeen written. These theoretical techniques are very relevant for DAPHNE physics.

PUBLICATION LIST

Joint Publications

- G. D'Ambrosio and J. Portolés, "Spin–1 resonance contributions to the weak Chiral Lagrangian : the vector field formulation",*Nuclear Physics*, **B533** (1998) 494–522, (hep-ph/9711211).

- G. D'Ambrosio and J. Portolés, "Analysis of $K_L \to \pi^+\pi^-\gamma$ in Chiral Perturbation Theory", *Nuclear Physics*, **B533** (1998) 523–554, (hep-ph/9711210).
- G. D'Ambrosio, G. Ecker, G. Isidori and J. Portolés, "The decays $K \to \pi\ell^+\ell^-$ beyond leading order in the chiral expansion", *Journal of High Energy Physics*, 08 (1998) 004, (hep-ph/9808289).
- A. Pich and J. Prades, *Perturbative quark mass corrections to the τ hadronic width*, J. High Energy Phys. 06 (1998) 013, 1–14.
- A. Pich and J. Prades, *Strange quark mass dependence of the tau hadronic width*, Proc. High Energy Conference on Quantum Chromodynamics –QCD'98– (Montpellier, France, July 1998), ed. S. Narison, Nucl. Phys. B (Proc. Suppl.) (1999) in press [IFIC/98-85, FTUV/98-84, UG-FT-76/97, hep-ph/9811263].
- T.-S.H. Lee, J.A. Oller, E. Oset, A. Ramos, *Non-perturbative chiral approach to $Kp \to \gamma Y$ reactions*, Nucl. Phys. A643 (1998) 402-414
- E. Oset, J.A. Oller, J.R. Pelaez, A. Ramos, *Meson-Meson and Meson-Baryon Interactions in a chiral Non-perturbative Approach*, Acta Phys. Polon. B29 (1998) 3101-3109
- E. Oset, A. Ramos, *Weak Decay of Lambda Hypernuclei*, Prog. Part. Nucl. Phys. 41 (1998) 191-253
- A. Ramos, E. Oset, *$\bar{K}N$ interaction and Kaons inthe nuclearmedium*, nucl-th/9810014
- E. Oset, J. A. Oller, J. R. Pelaez, A. Ramos, H. C. Chiang, F. Guerrero, S. Hirenzaki, T. S. H. Lee, E. Marco, J. C. Nacher, Y. Okumura, A. Parreno, H. Toki, M. Vicente-Vacas, *Recent progress on the chiral unitary approach to meson-meson and meson baryon interactions*, Proc. KEK-Tanashi International Symposium on Physics of Hadrons and Nuclei (Tokyo, Japan, 1998) in press [e-Print Archive: nucl-th/9902001]
- J.C. Nacher, E. Oset, H. Toki, A. Ramos, *Radiative production of the* $\Lambda(1405)$ *resonance in K collisions on protons and nuclei*, nucl-th/9902071

<u>Other Publications</u>

- D. Gómez Dumm and A. Pich, *Long–distance contributions to the $K_L \to \mu^+\mu^-$ decay width*, Phys. Rev. Lett. 80 (1998) 4633–4636.
- A. Pich, *Effective Field Theory*, Proc. Les Houches Summer School of Theoretical Physics –Probing the Standard Model of Particle Interactions– (Les Houches, France, July–September 1997), eds. F. David and R. Gupta (Elsevier Science B.V., Amsterdam, 1998) in press [IFIC/98-47, FTUV/98-46, hep-ph/9806303].
- M. Jamin and A. Pich, *Bottom quark mass from QCD sum rules for the Υ system*, Proc. High Energy Conference on Quantum Chromodynamics –QCD'98– (Montpellier, France, July 1998), ed. S. Narison, Nucl. Phys. B (Proc. Suppl.) (1999) in press [IFIC/98-76, FTUV/98-75, HD-THEP-98-50, hep-ph/9810259].

- D. Gómez Dumm and A. Pich, *Short and long–distance contributions to the rare decay $K_L \to \mu^+\mu^-$*, Proc. High Energy Conference on Quantum Chromodynamics –QCD'98– (Montpellier, France, July 1998), ed. S. Narison, Nucl. Phys. B (Proc. Suppl.) (1999) in press [IFIC/98-84, FTUV/98-83, hep-ph/9810523].
- F. Guerrero, *Study of the resummation of chiral logarithms in the exponentiated expression for the pion form factor.* Phys. Rev. D57 (1998) 4136-4141
- F. Guerrero and J.A. Oller, *$K\bar{K}$ scattering amplitude to one loop in chiral perturbation theory, its unitarization and pion form factors.*. Nucl. Phys. B537 (1999) 459-476
- J.A. Oller, *The $\phi \to \gamma K^0 \bar{K}^0$ Decay*, Phys. Lett. B426 (1998) 7-11
- J.A. Oller, E. Oset, *Theoretical Study of the $\gamma\gamma \to$ meson-meson Reaction*, Nucl. Phys. A629 (1998) 739-760
- J.A. Oller, E. Oset, A. De Pace, P. Fernandez de Cordoba, *Delta excitation in K^+-nucleus collisions*, Phys. Rev. C57 (1998) 1404-1409
- H.C. Chiang, E. Oset, M.J. Vicente Vacas, *Chiral nonperturvative approach to the isoscalar s-wave pion-pion interaction in a nuclear medium*, Nucl. Phys. A644 (1998) 77-92
- J.A. Oller, E. Oset, J.R. Pelaez, *Non-perturbative Approach to effective chiral Lagrangians and Meson Interactions*, Phys. Rev. Lett. 80 (1998) 3452-3455
- J.A. Oller, E. Oset, J.R. Pelaez, *Meson-Meson interaction in a non-perturbative chiral approach*, Phys. Rev. D59 (1999) 074001
- J.A. Oller, E. Oset, *N/D Description of Two Meson Amplitudes and Chiral Symmetry*, hep-ph/9809337
- E. Marco, S. Hirenzaki, E. Oset, H. Toki, *Radiative decay of ρ^0 and ϕ mesons in a chiral unitary approach*, hep-ph/9903217
- J. Bernabeu, F.J. Botella, O. Vives, *P odd observables at the Υ peak*, Eur. Phys. J. C7 (1999) 205-215

POST-DOCS

The UVEG node will hire **Ignazio Scimeni** (Italian; PhD in Rome 1998), starting in the fall of 1999.

LIST OF PARTICIPANTS

- Antonio Pich (8 m/y)
- Jorge Portoles (12 m/y)
- Eulogio Oset (4 m/y)
- Manuel Vicente (4 m/y)

- Franciso José Botella (6 m/y)
- Francisco Guerrero (12 m/y)
- José Antonio Oller (12 m/y)
- Eugenio Marco (12 m/y)

Travel Expenditures born by the Contract

- - VIIth EuroDAPHNE Coll. Meeting (Frascati, April 98): E. Marco, J.A. Oller, E. Oset, A. Pich
- - QCD98 Conference (A. Pich, Montpellier, July 1998)
- - Trip to Bern (J. Prades, from Granada, December 98)
- - Visits to Valencia of:

  L. Girlanda (Feb. 99), E. Pallante (Feb. 99), E. de Rafael (March 99)

PhD Thesis work related to DAΦNE physics

- - F. Guerrero, "Extension of ChPT to higher energies", PhD Thesis (advisor, A. Pich), Univ. Valencia, December 1998
- - E. Marco, "DIS of leptons with nuclei and related problems", PhD Thesis (advisor, E. Oset), Univ. Valencia, November 1998

Participant N.7 : UWIEN.ITP Inst. Theor. Physics, Univ. Vienna

Research Progress

In Ref. [1] a super-heat-kernel expansion was proposed to renormalize the one-loop generating functional for a general theory with bosons and fermions. This method was then applied in [6] to heavy baryon chiral perturbation theory with two flavours to third order in the chiral expansion. The previously known result was reproduced with substantially less effort. The extension to the three-flavour case is being pursued and will serve as a check of the existing calculation in the standard approach. The method can also be applied to perform the renormalization to fourth order in the chiral expansion. This extension is more complicated than the third-order calculation but once again the super-heat-kernel representation simplifies the calculation considerably.

A model-independent analysis of $K^+ \to \pi^+\ell^+\ell^-$ and $K_S \to \pi^0\ell^+\ell^-$ decays was performed, including $K \to 3\pi$ unitarity corrections and a general decomposition of the dispersive amplitude [2]. Consequences for the $K^\pm \to \pi^\pm e^+e^-$ charge asymmetries and for the $K_L \to \pi^0 e^+e^-$ mode were discussed. The decay $K_L \to \pi^+\pi^- e^+e^-$, with interesting CP violating asymmetries, is being recalculated to $O(p^4)$ as part of a PhD thesis (H. Pichl).

The divergent part of the mesonic generating functional of $O(p^6)$ was used to determine the leading infrared singular pieces of Green functions, the chiral double logs. All contributions of this type to the generating functional were given in closed form [3]. The results were applied to meson decay constants and form factors. The effective chiral Lagrangian of $O(p^6)$ was constructed in [4]. The minimal number of independent monomials was given both for a general number N_f of light flavours and for $N_f = 3$ and 2. The renormalization of the mesonic generating functional of $O(p^6)$ has nearly been completed.

The pion-nucleon chiral Lagrangian with virtual photons was constructed in [7] to fourth order in the chiral expansion. This allows the calculation of isospin violating effects in a systematic way. Electromagnetic corrections to the nucleon mass, sigma term and to the S-wave pion-nucleon scattering length were calculated.

A complete analysis of the electromagnetic corrections for the semileptonic decays of the light pseudoscalars requires an extension of the standard scheme of chiral perturbation theory by including the photon and the light leptons as explicit degrees of freedom. The theoretical basis for such an extended low-energy effective theory has now been worked out up to the one-loop level (M. Knecht, H. Neufeld, H. Rupertsberger and P. Talavera, in preparation). For the one-loop renormalization, super-heat-kernel methods have been employed and a complete list of the relevant counterterms has been given. As a first application, the decays $\pi(K) \to l\nu_l$ have been discussed. Further work on pionic β-decay, K_{l3} and K_{l4} decays is in progress. Of course, the K_{e4} decay is of particular interest for extracting the pion scattering lengths. For this, a reliable theoretical control of the electromagnetic corrections is needed.

Joint Publications

[1] H. Neufeld, J. Gasser and G. Ecker, The one-loop functional as a Berezinian, Phys. Lett. B438 (1998) 106. **Joint publication Bern/Vienna.**

[2] G. D'Ambrosio, G. Ecker, G. Isidori and J. Portolés, The decays $K \to \pi\ell^+\ell^-$ beyond leading order in the chiral expansion, JHEP 08 (1998) 004. **Joint publication Frascati/Naples/Valencia/Vienna.**

[3] J. Bijnens, G. Colangelo and G. Ecker, Double chiral logs, Phys. Lett. B441 (1998) 437.

Joint publication Lund/Vienna/Zürich.

[4] J. Bijnens, G. Colangelo and G. Ecker, The mesonic chiral Lagrangian of $O(p^6)$, JHEP 02 (1999) 020. **Joint publication Lund/Vienna/Zürich.**

Other Publications

[5] G. Ecker, Chiral symmetry, in Proc. of the 37. Int. Universitätswochen für Kern- und Teilchenphysik, Schladming, Austria, L. Mathelitsch and W. Plessas, Eds., Springer, 1999.

[6] H. Neufeld, The super-heat-kernel expansion and the renormalization of the pion-nucleon interaction, Eur. Phys. J. C7 (1999) 355.

[7] G. Müller and U.G. Meißner, Virtual photons in baryon chiral perturbation theory, hep-ph/9903375, submitted to Nucl. Phys. B.

Postdoctoral Researcher Financed by the Project

Dr. Guido Müller, German nationality, born 18.10.1967
period of appointment: 1.11.1998 – 31.10.2000
scientific speciality: P-01

Scientific Staff

scientist	man-months	percentage
Dr. Gerhard Ecker	8	67%
Dr. Guido Müller	5	100%
Dr. Helmut Neufeld	6	50%
H. Pichl	8	67%
Dr. Heinz Rupertsberger	4	33%

Networking costs paid by Vienna node

1. VIIth EURODAPHNE Collaboration Meeting, Frascati, April 1998, H. Pichl.
2. K_{e4} Working Group Meeting, Bern, June 1998, H. Neufeld.
3. VIIIth EURODAPHNE Collaboration Meeting, Paris, October 1998, H. Neufeld.
4. TMR-postdoc position, travel from Bonn to Vienna, November 1998, G. Müller.
5. Workshop on Chiral Effective Theories, Bad Honnef (Bonn), December 1998, G. Ecker, G. Müller and H. Neufeld.

Participant N.8 : DESY-IFH Zeuthen

One of the challenges of DaΦne is presented by the measurement of the total e^+e^-–hadronic cross-section, which provides information on the hadronic contributions to $(g-2)_\mu$ and $\alpha_{\rm QED}(M_Z)$. For the first quantity a new Brookhaven experiment (E821) has presented a first measurement, recently, and will improve the experimental accuracy by a at least an order of magnitude. In order to obtain an acceptable comparison between theory and experiment, this requires to reduce the uncertainty of theoretical predictions, which are dominated by the uncertainty of the hadronic cross-section at low energies. As long as DaΦne is operated at fixed energy as a Φ–factory a measurement of the hadronic cross–section is possible by analyzing the events where a hard photon has been radiated from the initial state. A detailed study of this process and the hadronic cross–section measurement is performed by the Karlsruhe group and is reported on seperately. The direct measurement of Sigma hadronic will require an upgrade of the machine and can only be done at a much later stage. It is under investigation at DESY Zeuthen. A complementary approach, which was advocated recently, suggests to rely more on perturbative QCD (pQCD) than on experimental data which exhibit large uncertainties. The reliability of pQCD has to be investigated more carefully, however. The Karlsruhe group has made major progress in calculating 3–loop massive vacuum polarization functions. Based on these results and a recent calculaton of the massive 2–loop beta function, the DESY Zeuthen group has started a detailed investigation of the validity of perturbative QCD towards lower energies. A new approach, based on Euclidean methods, yields promissing results, which also demonstrate, that the measurement of the hadronic cross–section at the low enegy end is much more important for reducing the uncetainty on $\alpha_{\rm QED}(M_Z)$ as well, while with the standard approach only the hadronic contribution to $(g-2)_\mu$ can be substantially improved at DaΦne energies.

Expenditures born by the Contract for the Zeuthen node

Travelling			Costs	
Name	Place	Date	ECU	DM
Hoefer	Frascati	Apr 98	941.05	1,858.10
Jegerlehner	Frascati	Apr 98	840.76	1,660.08
Pancheri	Zeuthen	Apr 98	506.46	1,000.00
Jegerlehner	Paris	Oct 98	862.88	1,703.76
Venanzoni	Zeuthen	Jan 99	308.97	610.06

Date	Topic	Input		Output	
		ECU	DM	ECU	DM
23.06.98	Transfer From Coordinator	46,500.00	91,814.54		
31.07.98	Transfer to subnode Karlsruhe			4,603.48	9,089.60
14.01.99	Transfer to subnode Karlsruhe			5,064.56	10,000.00
Jan 99	Grant payed to G. Venenzoni			2,279.05	4500.00
Feb 99	Grant payed to G. Venenzoni			2,279.05	4500.00
Mar 99	Grant payed to G. Venenzoni			2,785.51	5500.00
98	travellings			3,151.14	6,221.94
99	travellings			308.97	601.06
	sum			20,471.75	40,421.60
	overhead 14% of 40,421.60			2,866.04	5,659.02
	sum	46,500.00	91,814.54	23,337.79	46080.62

Exchange rate: 1 ECU = 1.97451 DM

List of Publications and Talks

F. Jegerlehner
Precision measurements of hadronic cross-sections at low energies.
EURODAFNE Meeting, LNF, Frascati, Italy (1998)

F. Jegerlehner, O.V. Tarasov,
Exact mass dependent two-loop $\bar{\alpha}_s(Q^2)$ in the background MOM renormalization scheme,
Preprint DESY 98-093, hep-ph/9809485, Nucl. Phys. B548 (1999) to appear.

F. Jegerlehner
Exact mass dependent two loop $\bar{\alpha}(s)(Q^2)$ in the background MOM renormalization scheme.
Symposium on Problems in Quantum field theory, JINR, Dubna, Russia (1998)

F. Jegerlehner, O.V. Tarasov,
Exact mass dependent two-loop $\bar{\alpha}_s(Q^2)$ in the background MOM renormalization scheme,
Preprint DESY 98-093, hep-ph/9809485, Nucl. Phys. B548 (1999) to appear.

F. Jegerlehner
Hadronic effects in $(g-2)_\mu$ and $\alpha_{\rm QED}(M_Z)$: Status and perspectives,
Preprint DESY99-007, hep-ph/9901386 Presented at the IVth International Symposium on Radiative Corrections, Barcelona, Sep. 1998 ed. J. Sola, World Scientific, Singapore, 1999

F. Jegerlehner
Problems with radiative corrections in pseudoscalar meson decays.
EURODAFNE Meeting, Univ. Pierre et Marie Curie, Paris (1998)

S. Eidelman, F. Jegerlehner, A.L. Kataev, O. Veretin
Testing non–perturbative strong interaction effects via the Adler function,
Preprint DESY 98-206, hep-ph/9812521, Phys. Lett. B (1999) to appear.

F. Jegerlehner
Hadronic contributions to $(g-2)_\mu$ and $\alpha(M_Z)$.
International Workshop e^+e^- Collisions from Φ to J/Ψ,
Budker Institute of Nuclear Physics, Novosibirsk, Russia (1999)

F. Jegerlehner
Sigma Hadronic and Precision Tests of the SM.
LNF SPRING SCHOOL and EURODANE Collaboration Meeting, Frascati, Italy (1999)

A. Hoefer
Theoretische Analyse Hadronischer Wirkungsquerschnitte.
Vortrag am 16.3.99 bei der DPG-Frühjahrstagung '99 in Heidelberg.

Postdoctorand

at Karlsruhe subnode (Prof. W. Kluge), working contract with DESY Zeuthen

Node Zeuthen (Subnode Karlsruhe see separate report)

Prof. Dr. Fred Jegerlehner, (6 month)
Dr. Oleg Veretin (postdoctorand), 4 month
Dr. Oleg Tarasov (guest scientist), 4 month
Axel Höfer (doctorand), 12 month

Activity Report

The activity of the Karlsruhe group has been focused on the idea of measuring hadronic cross sections at the electron-positron annihilation using photons radiated from the initial state (γ_{isr}). The feasibility of this method has been investigated from the theoretical point of view by S. Binner *et al.* (see [1, 2, 3, 4]) and within the KLOE environment by S. Spagnolo [1] It allows to vary continuously the energy of the hadronic state with fixed energies of the beams. In the particular case of DAΦNE the expected luminosity of $5 \times 10^{32} cm^{-2} sec^{-1}$ at $\sqrt{s} = M_\phi$ allows one to collect sufficient statistics during the running time devoted to the CP violation studies, in spite of the suppression of the production rate by a factor $\alpha_{e.m.}$.

Since the KLOE detector doesn't allow one to tag γ_{isr} at small angles ($\theta_\gamma < 7^o$), where the contribution of photons from the final state radiation (*f.s.r.*) can be neglected, a detailed simulation of both initial state radiation (*i.s.r.*) and *f.s.r.* processes has been developed. A Monte Carlo event generator of $\pi^+\pi^-\gamma$ events (with the photon emitted both from *i.s.r.* and *f.s.r.* and including collinear radiation) has been included in the Monte Carlo simulation program of KLOE. The full reconstruction procedure has been applied to the simulated events.

In order to identify $\pi^+\pi^-\gamma$ events with high efficiency and low background a selection procedure has been developed and tested with Monte Carlo events [5, 6]. The analysis proceeded in two steps:

1. in a first step $\pi^+\pi^-\gamma$events are selected, characterized by the following signature: (1) the presence of a charged vertex close to the interaction point, (2) a prompt photon hitting the Electromagnetic Calorimeter or an energy deposit in the Calorimeter covering the low β quadrupoles ($QCAL$) and (3) a cut on the invariant mass of the event. In this phase photons both from initial and final state radiation are accepted.

2. in a second step a favoured kinematical region of energies and angles of pions and photons is selected in order to reduce the contribution from the *f.s.r.*.

[1] S.Spagnolo The Hadronic Contribution to the Muon g-2 from Hadron Production in Initial State Radiation Events at the e^+ e^- Collider DAΦNE", Eur.Phys.J **C6** 637-645(1999) and LNF-98/028(IR).

A total cross section of $\sim 3.5\ nb$ and a ratio of *i.s.r.* over *i.s.r.+f.s.r.* larger than 99% has been found by combining cuts on the photon energy and polar angle ($E_\gamma > 50\ MeV$ and $10^o < \theta_\gamma < 40^o$ *or* $140^o < \theta_\gamma < 170^o$), on the pion polar angle ($20^o < \theta_{\pi^+,\pi^-} < 160^o$) and on the angle between one of the pions and the photon.

Contributions from the main background sources (*e.g.* $e^+e^- \rightarrow \mu^+\mu^-\gamma$, or $\phi \rightarrow \pi^+\pi^-\pi^0$) can be discriminated by a global fit.

Preliminary results regarding the statistical errors and systematics effects (due to the misalignment of the detector or to the experimental resolution) look very promising with respect to achieve the required level of accuracy, also at the reduced luminosity to be expected at the beginning of data taking.

Work is going on in order to refine the Monte Carlo generation (including the treatment of the interference of the *f.s.r.* with the $\phi \rightarrow f_o\gamma \rightarrow \pi^+\pi^-\gamma$ decay) and to understand better the systematics, using real data in the next months.

An important tool in the separation of initial *versus* final state radiation is the charge asymmetry between $\pi^+$and π^- in the interference term. A similar mechanism is also operative in heavy quark production of hadron colliders and has been studied in [7].

List of publications

1. S. Binner, J. H. Kühn and K. Melnikov 'Measuring $\sigma(e^+e^-\ to\ Hadrons)$ Using Tagged Photon' Report TTP99-09 and hep-ph/9902399.
2. K. Melnikov 'Measuring $\sigma(e^+e^-\ to\ Hadrons)$ at DAΦNE using tagged photons', talk at VIIIth EuroDaphne Collaboration Meeting, University Pierre et Marie Curie, LPNHE3, Paris, Oct. 19-21.
3. K. Melnikov, 'Measuring $\sigma(e^+e^-\ to\ Hadrons)$ at DAΦNE using tagged photons', talk at the International Workshop on e^+e^-collisions from ϕ to J/ψ, Novosibirsk, March 1- 5, 1999.
4. J. H. Kühn, 'Measuring $\sigma(e^+e^-\ to\ Hadrons)$ Using Tagged Photon', talk at the LNF Spring School, Frascati, April 12-17, 1999.
5. A. Denig, Ph.D. Thesis, Karlsruhe 1999, unpublished, 'Aufbau, Automatisierung und Test eines Gassystems fur die KLOE-Driftkammer und Untersuchungen zur Messung der Pionpaarerzeugung mit Photonenabstrahlung bei DAΦNE' (in German).
6. G. Venanzoni, 'Measurement of Hadronic Cross Sections with a Radiated Photon in the Initial State with the KLOE Detector', talk at the LNF Spring School, Frascati, April 12-17, 1999.
7. J. H. Kühn and G. Rodrigo 'Charge Asymmetry of Heavy Quarks at Hadron Colliders' Phys. Rev. **D 59** (1999) 05 4017 TTP98-15, hep-ph/9807420.

Details of Costs financed by the network

The Karlsruhe subnode has received DM 19 089.60 from DESY-Zeuthen in 1998 and 1999 and spent up to date about DM 10 000.00 for the following research related trips:

1. Kluge, Wolfgang: EURODAFNE Paris 18.-22.10.98 DM 990.29
2. Denig, Achim: EURODAFNE Paris 18.-22.10.98 DM 854.43
3. Melnikov, Kirill: EURODAFNE Paris 18.-22.10.98 DM 798.03

4. Venanzoni, Graziano: Frascati 21.3.-3.4.99 DM 2118.07
5. Venanzoni, Graziano: Frascati 14.-23.4.99 DM 1847.71
6. Kuehn, Hans: Frascati 15.-19.4.99 DM 1541.03
7. Melnikov, Kirill, Novosibirsk, 28.2.-6.3.99 ca.DM 1700.00 (not yet finally calculated)

Note that permission was granted for Melnikov travel outside the EU.

Postdoctorand

Name and nationality:	Venanzoni, Graziano IT
date of birth:	17.05.1969
start date and likely duration in months:	01.01.1999, 18 months
category of researcher:	postdoctorand
scientific speciality:	P01
list of publications in refereed journals:	none

Subnode Karlsruhe

Prof. Dr. Johann H. Kühn
Silja Binner (diplomand)
Dr. Aude Gehrmann
Dr. Kirill Melnikov

Prof. Dr. Wolfgang Kluge
Achim Bankamp (diplomand)
Dr. Gabriella Cataldi
Achim Denig
Chen Chen Kuo
Stefan Müller (diplomand)
Dr. Graziano Venanzoni

Participant N.9 : UH.DPHY University of Helsinki

1. Scientific progress and 2. Publications

Subnode LUND:

CP and CPT physics in the kaon system: paper 1 and 2 have provided significant progress toward the calculation of ϵ'/ϵ. Within the expected error of the method we have reproduced the main part of the $\Delta I = 1/2$ method which is a first major test. This project is on schedule.

Theoretical issues in ChPT: Standard ChPT : the main new predictions of ChPT at order p^6 were calculated in a general manner [4] and the total number of new parameters at the same order has been worked out [6]. This is also on schedule with the expectations.

Chiral Symmetry Breaking: The work of [3] showed that in the scalar form factor no new scalar particle at low energy is needed and that the two-loop expression perfectly fits the data.

K-decays: $K \to \pi\pi$ see above in [1] and [5], in K_{e4} a simpler method to extract the phase shifts from the data has been proposed and its adequacy tested against existing models and calculation. The full two-loop calculation is work in progress. We are also involved in the calculation of QED radiative corrections to all semileptonic decays together with UWIEN and Marseille.

$\pi\pi$ scattering at threshold, the proposed Lund part of this project was actually finished before the actual start of the project.

Vector mesons in Effective lagrangians: We have evaluated chiral corrections to the vector decay constants and found them to be of reasonable magnitude [2].

In addition paper [3] contains calculations relevant to $e^+e^- \to$ hadrons near threshold and on the very low energy contribution to $(g-2)_\mu$.

Publications:

1. Obtaining $K \to \pi\pi$ from Off-Shell $K \to \pi$ Amplitudes
   J. Bijnens, E. Pallante and J. Prades, *Nucl. Phys.* B521 (1998) 305
   UHELS-UBERN-UAB

2. Chiral Corrections to Vector Meson Decay Constants
   J. Bijnens P. Gosdzinsky and P. Talavera, *Phys. lett.* B429 (1998) 111
   UHELS-UAB

3. The Vector and Scalar Form Factors of the Pion to Two Loops
   J. Bijnens G. Colangelo and P. Talavera, *JHEP* 05 (1998) 014
   UHELS-INFN-UAB

4. Double Chiral Logs
   J. Bijnens G. Colangelo and G. Ecker, *Phys. lett.* B441 (1998) 437-446
   UHELS-INFN-UWIEN

5. The $\Delta I = 1/2$ Rule in the Chiral Limit
   J. Bijnens J. Prades, *JHEP* 01 (1999) 023
   UHELS-UAB

6. The Mesonic Chiral Lagrangian of Order p^6
   J. Bijnens G. Colangelo and G. Ecker, LU TP 99-2, 21p.,hep-ph/9902437, accepted

for publication by *JHEP*.
UHELS-UBERN-UWIEN

7. A Parametrization for $K^+ \to \pi^+\pi^-e^+\nu$
G. Amoros and J. Bijnens , LU-TP-99-05, 18p., hep-ph/9902463, submitted to J. Phys. G
UHELS

They are all joint with at least one more of the nodes except for the last one which is with the network postdoc.

Node Helsinki:

NAT has studied light meson spectroscopy, mainly the scalar resonances, candidates for exotic mesons and glueballs (which are his main responsibilities within the Particle Data Group).

He has discussed the question whether the light and broad σ (500) exists, and in particular he has studied the well known linear sigma model and compared its predictions to present data. He has pointed out the remarkable good predictions of this 30 year old model already at the tree level to the scalar and pseudoscalar mass spectrum, and in particular to recently measured scalar meson couplings to two pseudoscalars ($g_{\sigma\pi\pi}$, $g_{\sigma K\bar{K}}$, $g_{\kappa K\pi}$, $g_{\kappa K\eta}$, $g_{f_0\pi\pi}$, $g_{f_0K\bar{K}}$, $g_{a_0\eta\pi}$, $g_{a_0K\bar{K}}$).

Publications:

- Review of Particle Properties (1998 Edition). With the Particle Data Group: C. Caso, G. Conforto, A. Gurtu, M. Aguilar-Benitez, C. Amsler, R.M. Barnett, P.R. Burchat, C.D. Carone, O. Dahl, M.Doser, S. Eidelman, J.L. Feng, M. Goodman, C. Grab, D.E. Groom, K. Hagivara, K.G. Hayes, J.J. Hernandez, K. Hikasa, K. Honscheid, F. James, M.Mangano, A. Manohar, K. Mönig, H. Murayama, K. Nakamura, K. Olive, A. Piepke, M. Roos, R.H. Schindler, R.E. Shrock, M. Tanabashi, N.A. Törnqvist, T.G. Trippe, P. Vogel, C.G. Wohl, R.L. Workman, W.-M. Yao, The European Physics Journal (July 1) **C3** (1998).

- On loop Corrections in the Linear Sigma Model, Nils A. Törnqvist,

1) Talk at the Third International Conference on Quark Confinement and the Hadron Spectrum, Jefferson Lab, Newport News, VA, USA, 7.6-12.6 1998. To appear in proceedings Ed by N. Isgur et al. World Scientific. And

2) Talk at the International Conference QCD98 at Montpellier, France, 2-8th July 1998, To appear in Nuclear Physics conference proceedings Ed by S. Narison et al.

- Does the Light and Broad σ(500) Exist? Nils A. Törnqvist, hep-ph/9904346. Talk at the Workshop of Hadron Spectroscopy, March 8-13 1999, Frascati, Italy. To appear in the Frascati Physics Series.

- Comparing the Broken U3 $\times$ U3 Linear Sigma Model with Experiment. Nils A. Törnqvist, (in preparation.)

The scientific work of Mikko Sainio has focused on pion-pion and pion-nucleon interaction. The publications [1] and [2] report on methods for evaluating two-loop integrals encountered in chiral perturbation theory. In the pion-nucleon sector the main problem has been phenomenological work related to the extraction of coefficients in pion-nucleon subthreshold expansion and the Goldberger-Miyazawa-Oehme sum rule.

Publications:

1. Two-loop integrals in chiral perturbation theory
   J. Gasser and M.E. Sainio, *Eur. Phys. J.* C6 (1999) 297
   UHELS-UBERN

2. Pion-pion scattering at low energy
   M.E. Sainio, *Proc. Int. Workshop Hadronic Atoms and Positronium in the Standard Model*, JINR, Dubna, May 26-31, 1998, Eds. M.A. Ivanov et al., p. 9.

3. Post-docs:

Gabriel Amoros (Lund), postdoc funded by the network, in Lund/Helsinki since 1/11/98.
spanish,
date of birth: 27 January 1971,
likely duration of the appointment is 24 months.

4. Individuals involved:

1. Nils Törnqvist (Helsinki), senior researcher, scientist-in-charge, 7 man-months
2. Gabriel Amoros (Lund), postdoc funded by the network, in Lund/Helsinki since 1/11/98, 5 man-months of training, expected to be continued for another 19 months
3. Johan Bijnens (Lund), senior researcher, 11 man-months, whole duration
4. Mikko Sainio (Helsinki), senior researcher, 7 man-months
5. Pere Talavera (Lund), postdoc, funded by NFR the Swedish science foundation, in Lund since 1/10/98, 6 man-months

5. Details of Costs borne by the Contract

- post doc (Amoros) 11983.39 EURO
- subcontractor (Lund) 2550.60 EURO
- networking (travel)
  1. -EURODAPHNE meeting Frascati 14-19.4.1998 M. Sainio 1208.08 EURO
  2. -EURODAPHNE working group meeting, Bern 29-30.6.1998 M. Sainio 68.52 EURO
  3. -EURODAPHNE meeting Paris 17-22.10.1998 N. Tornqvist 1086.00 EURO
- overhead 2869.20 EURO =============
- Total 19765.79 EURO

Participant N. 10 : UBERN.ITP University of Bern

TO SHARPEN THE PREDICTIONS OF CHPT

Our node was mainly concerned with this part of the Project objectives listed in section 2 of the Programme. There are three main themes:

i) Roy equations. These are the mathematical tool that will allow one finally to extract, with the help of data taken with KLOE, the S–wave pipi scattering length a_0. In order to achieve this goal, one has to solve a coupled system of nonlinear, singular integral equations fort the three lowest partial waves. We now understand fully the mathematical properties of the system in the one–channel as well as in the multichannel case. In particular, we have constructed the universal band in the $a_0 - a_2$ plane of S–wave scattering lengths, and for a set of points in this band we have generated numerical solutions of the Roy equations. This result allows us to give a region in the universal band which is consistent with available low– and medium–energy data. The relevant publication is in preparation right now.

This result contributes to point 8 in the milestones.

We have begun to use this information to work out the prediction for the threshold parameters of pipi scattering in the framework of standard chiral perturbation theory. We expect this result to be ready in fall 99. It corresponds to point 7 in the milestones: Whereas the amplitude has already been algebraically evaluated at order p^6, the use of the Roy equations will allow us to pin down the low–energy constants that occur in the low–energy representation.

ii) The DIRAC experiment, presently running at CERN, aims to measure the lifetime of $\pi^+\pi^-$ atoms. This will allow one in turn to evaluate the combination $|a_0 - a_2|$ of S-wave scattering lengths, provided one has a formula that relates the lifetime and $|a_2 - a_0|$. We have spent a considerable amount of time to develop methods that allow one to describe unstable atoms in the framework of Quantum Filed Theory. We have made a breakthrough in the sense that we can provide the necessary link in a straightforward and clear manner. It is at the same time the first result that has all the corrections at next-to-leading order in an expansion of the lifetime in powers of alpha and of the quark mass difference $m_u - m_d$. The method extends nearly trivially to the case where spin is involved, like in meson-nucleon atoms, studied at PSI and to be studied at DEAR.

iii) It is not easy to maintain power counting in pion-nucleon chiral perturbation theory. For a long time, so called heavy baryon chiral perturbation theory was used for this purpose. Our group has developed in the last year a powerful method that allows one to perform the calculations in a manifestly Lorentz invariant form. This method is an alternative to Heavy Baryon Chiral Perturbation Theory: one simply has to perform the calculations in the relativistic framework by using a well defined set of rules in dimensional regularization. The field of applications is very wide – among others, DEAR at DAFNE.

iv) Our group has started to extend the chiral expansion the η' in a systematic fashion. As KLOE will provide a huge amount of data on eta' and eta radiative and nonradiative decays, the range of applications here is obviously also very wide.

Joint publications:

[1] J. Gasser and M. E. Sainio, Two-loop integrals in chiral perturbation theory, Eur.Phys.J. C6 (1999) 297-306.

[2] H. Neufeld, J. Gasser and G. Ecker, The one-loop functional as a Berezinian, Phys. Lett. B438 (1998) 106-114.

[3] Ll. Ametller, J. Kambor, M. Knecht and P.Talavera, Low-energy photon-photon fusion into three pions in Generalized Chiral Perturbation Theory, hep-ph/9904452.

I have not noted the ones Gilberto Colangelo wrote with Hans Bijnens, Gino Isidori and Gerhard Ecker, as I believe that they have already written those.

Others Publications

[1] E. Pallante, The quenched generating functional for hadronic weak interactions, talk given at LATTICE98, hep-lat/9810012.

[2]Joachim Kambor and Martin Mojzis, Field Redefinitions and Wave Function Renormalization to $O(p^4)$ in Heavy Baryon Chiral Perturbation Theory, hep-ph/9901235.

[3] Robert Baur and Joachim Kambor, Generalized Heavy Baryon Chiral Perturbation Theory Eur.Phys.J. C7 (1999) 507-524.

[4] R. Kaiser and H. Leutwyler, Pseudoscalar Decay Constants at Large N_c, hep-ph/9806336.

[5] T. Becher and H. Leutwyler, Baryon Chiral Perturbation Theory in Manifestly Lorentz Invariant Form, hep-ph/9901384, to be published in Eur.Phys.J.

[6] J. Gasser and G. Wanders, One-channel Roy equations revisited, hep-ph/9903443, to appear in EPJC.

[7] J. Gasser, pipi scattering at low energy: status report, in: Proceedings of the International Workshop "Hadronic Atoms and Positronium in the Standard Model", Dubna, Russia, May 26-31, 1998, edited by M.A. Ivanov et al. (Dubna 1998), and hep-ph/9809280.

[8] J. Gasser, Chiral Dynamics, International Workshop e^+e^- Collisions from Φ to J/Ψ, Budker Institute of Nuclear Physics, Novosibirsk, Russia (1999), to appear in the proceedings

[9] J. Kambor, Introduction to chiral perturbation theory,
Proc. of the Summer School on Hidden Symmetries and Higgs Phenomena, Zuoz, Switzerland, Aug. 16-22, 1998.

PhD thesis work related to DAFNE physics:

- Arnold Roessl, pi K scattering near the threshold in chiral SU(2) perturbation theoryx, PhD thesis, Univ. Bern, hep-ph/9904230
- Alex Gall, Matching in Nonrelativistic Effective Quantum Filed Theories, PhD thesis, Univ. Bern, Dec. 1998.

Diploma thesis work related to DAFNE physics:

- Manuel Walker, eta to 3pi decays, diploma thesis Univ. Bern, Dec. 1998.
- J. Kaeppeli, Quark masses and quark mixing, diploma thesis, Univ.Bern, Dec. 1998.

- Schaerli Andrea, Positronium and Pionium, diploma thesis, Univ. Bern, 1999.

Postdocs
We have had no postdoc in this period.

Months spent

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Bern
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Antonelli 5man months   100% for 5 months
Pallante  5             100% for 5 months
Rusetsky  7             100% for 7 months
Gasser    6             50%
Leutwyler 2             20%


Gall     12             100%  9month as a PhD student
Becher   12             100%  PhD student
Schaerli 12             100%  diploma student
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Total    61

8 researchers

Zuerich
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Kambor   12             100%
Colangelo  9            100% since September
Wyler     2

Buechler 12             100% PhD student
Orellana 12             100% PhD student
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Total    47

5 researchers

Grand total   108 months
              13 researchers

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Travels and Workshops

- We had organized a workshop dedicated to the analysis of Ke4 decays on June 29/30, 1998, in Bern. There were many members of the node, including physicists from outside the network (Brookhaven and Yale). The programme is appended below, including the title of the talks and the summary provided by Mike Pennington (in latex)
- Gasser was invited to attend the International workshop on e^+e^- collisions in Novosibirsk (March 1 to 5) and to report on chiral dynamics in connection with the physics programme at DAFNE.

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K14 workshop, June 29/30, 1998, Bern

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             1. TIME SCHEDULE

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             Monday, June 29
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9:00   M. Pennington
       $K_14$ data and previous data analyses


9:40  S. Pislak
       E865 experiment and analysis

       Discussion of questions, see attached e-mail


       Coffee break

11:30  P. de Simone  Status of KLOE


around 13:00  Lunch


14:30
       G. Wanders
       Uniqueness problem in solving Roy equations
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15:10  Ananthanarayan
       Driving terms in Roy's equations


15:50  Coffee break


16:30  G. Colangelo
       Solving Roy equations numerically




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       Tuesday, June 30
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9:00   Jan Stern

       Energy independent versus energy dependent extraction of
       pipi phases from $K_e4$ experiment

9:40  N. Fuchs
       Analysis of $K_e4$ form factors in $O(p^4)$ GCHPT

10:20 Coffee break


11:00  M. Knecht
       Radiative corrections in semileptonic kaon decays


       Free discussions among participants (tables are available)

       e.g. - proposals how to analyse $K_e4$ data
            - action programme

13:00  Lunch

       Free discussions among the participants
            - see above

16:30  Presentations of results from discussions
       Formulation of action programme

       End of workshop
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Summary of Workshop

K_{e4} EuroDAΦNE Working Group

Meeting of June 29th and 30th, 1998, Bern
Summary of Work Programme

A very useful meeting was held at the University of Bern, organised by Jürg Gasser and Gilberto Colangelo, with 15 participants. There were 9 talks covering the background theory and past analyses of $K_{\ell 4}$ decays by Michael Pennington, the status of BNL E865 experiment by Stefan Pislak, the prospects for KLOE By Patrizia de Simone, the Roy equations for low energy $\pi\pi$ scattering — their solutions by Gilberto Colangelo, their driving terms by Ananthanarayan and uniqueness by G. Wanders, Pais-Treiman analysis and model-dependences by Jan Stern, $K_{\ell 4}$ form-factors in GχPT by Norman Fuchs and radiative corrections by Marc Knecht.
As a result of discussions, the following topics were identified for future work.

- **Radiative Corrections**. A group led by Marc Knecht will continue to work on this topic. Their first task is to estimate the low energy constants, and from these to get an idea of the cuts needed to minimise the effect of radiative corrections in K_{e4} decays.

  They will then continue to study radiative corrections for the series of decays $\pi_{\ell\ell}$, $K_{\ell\ell}$, $K_{\ell 3}$, $K_{\ell 4}$ using the effective field theory formulation.

  They will investigate summation techniques for Coulomb terms at low momentum q, where the effective expansion parameter becomes α/q.

- **$\pi\pi$ phases.**

  General parametrization techniques will be considered by G. Wanders.

  An *effective* effective range formula satisfying the Roy equations in terms of a single parameter, e.g. a_0^0, will be developed by Colangelo et al. and considered by Stern et al.

  An estimate of the errors on the Roy equation solutions from the uncertainties on the input data will be made.

  Both the last two items will be expressed in terms of the phase difference $\delta_0^0 - \delta_1^1$, so that this can be input directly into the K_{e4} analysis.

- **$K_{\ell 4}$ form-factors.**

  A need to understand the dependence of the form–factors F, G, H, R on s_ℓ and s_π and the related analytic structure of the form-factors was identified. The minimal suggestion was that F, G are linear in s_ℓ and s_π, H is constant and for $e\nu$ final state R can be neglected. Hans Bijnens agreed to estimate the dependences on s_ℓ and s_π.

  Isospin violating effects: understanding these is needed to relate the form-factors f, g, h in $K^\pm \to \pi^+\pi^- e^\pm \nu$, $K^\pm \to \pi^0\pi^0 e^\pm \nu$ and $K_L \to \pi^0\pi^- e^+ \nu$ decays. The first question is *are $m_u - m_d$ effects* wholly accounted for by using the appropriate phase-space factors for each process. Jürg Gasser agreed to think about this.