42nd MEETING OF THE LNF SCIENTIFIC COMMITTEE
FINDINGS AND RECOMMENDATIONS

INTRODUCTION

This meeting of the Scientific Committee (SC) was the first since the approval of the SuperB project by the Italian government.
The program of open session of 6 June was set up to review the status of DAΦNE and of its experimental program, as well as the status and planning of SuperB and of the photon science initiatives at LNF.
The closed session of 7 June dealt chiefly with near- and mid-term scenarios, in which the DAΦNE and SuperB activities must be jointly considered. The (then) interim Director U. Dosselli extensively informed the Committee about the new INFN institutional layout and developments and very preliminary plans. Inputs were given by M. Giorgi regarding SuperB and by P. Raimondi, regarding SuperB, DAΦNE and its experimental program.
The Committee membership is evolving. G. Colangelo from the University of Bern was appointed to the SC, while G. D'Ambrosio's second 3-year appointment had come to its end. G. D'Ambrosio kindly participated in this meeting and was thanked for his excellent services. J. Rossbach's first 3-year term was renewed. The second terms of L. Fayard, J. Jowett and J. Zinn-Justin will have run out by the time of the next SC meeting; the Director will propose replacement members to INFN management. The mandates of the chairs of INFN National Scientific Committees CSN1 and CSN3 are over, however their successors have not been chosen yet. The Director is invited to consider inviting the new CSN chairs to take part in the SC meetings, as observers, as done by the previous Director, M. Calvetti.

1. NEWS FROM THE DIRECTOR

U. Dosselli, interim Director since January 2011, gave a comprehensive report on the developments of the last several months.

42nd LNF Scientific Committee – Findings and Recommendations

Changes in INFN statutes

The Italian government reformed the statutes of all national research agencies. INFN management was able to keep these changes to a minimum. The President will be designated by the Board of Directors, as in the past; the nominee will have to be endorsed by the government, which is the normally expected outcome. The length of terms of the President and of many other management positions will increase from 3 to 4 years, with the possibility of a second mandate. R. Petronzio cannot be re-elected, having served two terms; however the government has not decided the length of his current interim mandate; this should be clarified in a matter of weeks. A new Director General position has been created; this person will be appointed by the President, will serve for the duration of the mandate of the latter and will have mostly administrative responsibilities. There will also be a new Technical and Scientific Committee, to assist management in prioritizing strategically significant choices – for instance, between experiments recommended for approval by different National Scientific Committees (this Committee is not to be confused with the International Evaluation Committee, which has very high scientific profile and meets only once a year).

Concerning the appointment of directors of national labs such as the LNF, the procedure is now as follows: first, the laboratory staff is requested to vote among competing candidates. Then the INFN president appoints a search committee, which may add up to two more candidates to the candidate voted by the lab. The Board of Directors makes the final choice. The LNF staff's vote was scheduled for 9 June, with U. Dosselli being the only candidate.

Summary of LNF activities

Next, U. Dosselli gave a quick review of the laboratory's activities, pointing first at a few notable facts:

- P.L. Campana from LNF is about to become the spokesperson of LHCb.
- About 50 LNF physicists are involved in LHC experiments. This is almost ½ of the research division.
- The laboratory staff is about 20% of INFN's total staff.
- Over the next few years, retirements will strongly reduce the LNF staff, because new regulations only allow to replace about one person in 4 (when the new person has lower seniority).

He then discussed in more depth three programs: DAΦNE, Photon Science and SuperB.

DAΦNE

U. Dosselli stated that the laboratory is committed to running DAΦNE and to delivering the luminosity needed to make KLOE a successful experiment. He sees 2-3 years as the likely time frame of KLOE. Other DAΦNE activities must be viewed in the context created by SuperB. DAΦNE should run while SuperB is not yet being built. As SuperB construction begins, DAΦNE running should be winding down. Running DAΦNE costs 4-5 M€/year, however these funds come directly from INFN without passing through the lab. The syncrotron light program must also continue while DAΦNE runs.

Photon Science

INFN is strongly committed to the SPARC program. An important reason for not wanting SuperB on LNF grounds was that this would have been only marginally compatible with SPARC. INFN's view of SPARX is different, because something like 50 M€ are missing from its funding, and INFN is not the main actor on this project. INFN supports building a smaller facility, "SPARXINO", as an addition to SPARC. Dosselli stated that the money committed to this project by agencies other than INFN can be recovered.

SuperB
(information obtained from M. Giorgi and P. Raimondi later in the closed session is included in the Director's report)

The concept and goals of the project are well-known and will not be repeated here. The machine design, the physics program and the detector, basically the upgraded BaBar detector, were described by M.Giorgi and P. Raimondi in the open session of this meeting.

SuperB was approved in December 2010 (a few days after the 41st meeting of the SC), and funded with 19 M€ in 2010 and 250 M€ for the quinquennium 2011-2015. The time profile of 2011-15 funding is not known. The project will also receive manpower and in-kind contributions from SLAC, the latter consisting of major parts of the de-commissioned PEP-II rings, foremost among those the RF components. Manpower contributions are expected from IN2P3, and further in-kind contributions from Russia are being negotiated, in exchange for Italian participation in an Ignitor machine based in Russia. The project is listed in first priority in the new category of flagship research projects, which are given a specific budget line. As such, the SuperB project will be funded separately from the INFN base budget. (It was understood that as result of new regulations in the funding of Italian research agencies INFN base budget for 2011 may be 1%-2% lower than in 2010).

The site of SuperB has been chosen. It will be on the campus of the Tor Vergata (Roma 2) University, only a few km from LNF. The site complies with the geological and technical requirements. Tor Vergata strongly supports the project, and its engineering faculty wants to get strongly involved with the project. The collider will also feature many synchrotron radiation lines – both on the high-and low-energy rings – which, by virtue of the unprecedented small emittance of the beams, will establish a new frontier in this field. These lines will be funded by the Italian Institute of Technology (IIT).

To carry out the project it is planned to form a Consortium, involving 4 partners (INFN, Tor Vergata, the IIT, and the Research Ministry. The Consortium should be formed on a very short time scale (weeks) while the international participation is under discussion.

Shortly before the SC meeting a kick-off meeting took place in Elba, with the participation of over 200 persons, showing the existence of a large community of interested physicists in Italy and elsewhere.

The first challenge faced by INFN and its partners is to specify the crucial aspects of this project – international structure, funding, technical design, the management structure, the team needed for machine construction, the schedule – on a very rapid time scale. These plans will be presented to ECFA. The main challenge is to have a machine collecting data without significant delays with respect to the Super KEK-B project.

The discussion and the recommendations of the Scientific Committee are given after J. Jowett's report on DAΦNE and the SuperB plans.

2. ELECTRON COLLIDERS, STATUS AND PLANS

Following the corresponding presentations in the open session, J.M. Jowett met with members of the Accelerator Division to discuss the status of DAΦNE and the Division's activities related to SuperB.

2.1 DAΦNE

At the last meeting the Committee had already been expecting DAΦNE to be delivering luminosity to KLOE2 but this had not happened because of faults with the superconducting solenoid; these had emerged in early summer 2010 and took until November to resolve. Nevertheless, there were favourable indications that the machine was otherwise in good shape and re-commissioning with the new KLOE2

interaction region exploiting the crab-waist scheme was going well. The Committee was accordingly optimistic that regular high-luminosity operation would have been well established by now.
These hopes have been dashed again by a sequence of hardware failures resulting in a delay of the KLOE2 physics programme by more than a year. Re-commissioning will not re-start until October and luminosity production in early 2012 at best.

2.1.1 Hardware problems

The failure of the positron injection septum meant that no positrons could be injected for the first 3 months of 2011. No spare coils were available despite the need for frequent repairs of these highly stressed components during their 15 years of operation. It was stated that a procedure to order spares was embarked upon earlier in 2010 but the difficulty in finding appropriate manufacturers and the tendering process required for these expensive items meant that the order could only be placed in November 2010.

Positron injection was restored in early April thanks to a substitute coil constructed with a conductor obtained from CERN. We note that the design of the new coils now being delivered to equip all the injection kickers will halve their power consumption.

At its meeting in November 2008, the Committee noted concerns in the Accelerator Division related to the deteriorating performance of the linac gun cathode which had then been operating for 12 years. The availability of spares from the original supplier was not clear at the time. In October 2009, the Committee was informed that a stock of spares had been located in the lab. One of these two spares was installed in February 2010 and lasted until December. The last spare then lasted only one week. It seems reasonable to conclude that long-term storage is deleterious to these components. A smaller substitute cathode obtained from SLAC worked intermittently until 25 May when DAΦNE finally had to be shut down.
Several new cathodes were ordered in April but will not arrive until September. Given their vital role for operation of the entire complex and their relatively modest cost (about $7000 each) it is difficult to see why they should not have been ordered much sooner.

Other faults such as the ceramic window in the positron production demodulator and the KLOE magnet power supplies are symptomatic of a general ageing and wear of many components of the collider and its injectors. The Committee learned that signs of other impending problems (contamination of waveguides by discharges, etc) are apparent.

2.1.2 DAΦNE operation

Between the interruptions, it has been possible to make a certain number of low-intensity studies of DAΦNE. These generally indicate that the ring optics is in good shape, with very good agreement between the theory and measurements for the linear optical functions, dispersion and chromaticities. There is evidence that the various improvements made to the hardware of the ring have been successful.

Measurements of nonlinear feed-down effects by displacing the orbit in the wigglers show that the modifications made to the wiggler poles have successfully eliminated most of the undesirable multipole components that existed in the wiggler field distribution, an important step-forward for the collider performance.

Efforts are being made to eliminate a 0.4 mm oscillation of the vertical closed orbit, apparently arising in the defocusing quadrupoles of the low-beta section. These must be pursued to restore proper conditions for the synchrotron radiation users. Although there happens to be no direct effect on luminosity, this is also a very undesirable feature for collider operation.

The DAΦNE team has been able to carry out detailed studies to understand the betatron coupling and the first luminosity scan at low intensity has achieved a smaller vertical beam size *with the KLOE solenoid* than the best previously achieved without it for SIDDHARTA. Together with promising indications for the specific luminosity, this is a very encouraging result.

Measurements of bunch lengthening with intensity in the electron ring have shown that the coupling impedance of the electron ring has been reduced by 25% thanks to the modifications of the vacuum chamber. There are first indications of a similar improvement in the positron ring despite the installation of electrodes to combat the electron cloud effect.

The substantial upgrades to the feedback systems have gone smoothly. The improvements to the transverse feedback have already shown their worth with the new capability to make the first vertical decoherence measurements. The Committee looks forward to further results and analysis.

Given the fragmented and limited time available so far (just a couple of hours of colliding beams in May) these are still early days for the commissioning of the new KLOE2 configuration. Much work remains to be done to ramp up the intensity and luminosity and face the challenges that lie ahead.

2.1.3 General remarks on DAΦNE

The physics programme that has been approved for the coming years requires DAΦNE to perform as a state-of-the-art high luminosity collider. Achieving and sustaining the necessary luminosity with the new interaction region exploiting the crab-waist principle is far from being a routine matter. The Accelerator Division must be able to devote sufficient attention, material resources and expertise to this task, at least in accordance with the list of items given at the end of C. Milardi's presentation. In particular, the Committee recommends that a coherent spares policy be implemented. This is necessary, first of all to eliminate critical vulnerabilities like those described above and, secondly, to maintain reliability and avoid unnecessary interruptions to operation for physics. Now, while the accelerators are shut down, is a good time to inspect, repair and refurbish as far as practically possible. More substantial work can be carried out with further spares delivered by the time of the stop foreseen in 2012.

If installation of SIDDHARTA2 in the second interaction region is to go ahead, resources will be stretched even further. It will also be important to ensure that the necessary know-how to execute efficiently the detailed design remains available in the Accelerator Division at the time it is needed.

2.2 THE SUPERB PROJECT IN THE LNF ACCELERATOR DIVISION

The Committee appreciated P. Raimondi's very interesting presentation of the main design features of the SuperB factory. We congratulate the project team on the approval by the Italian government since our last meeting and conclude that the DAΦNE energy upgrade that we were then considering will not be pursued further.

It is clear that the SuperB design is one of the most challenging accelerator projects ever conceived. It builds on the remarkable, hard-won successes of a number of predecessors (DAΦNE, for the crab-waist concept in particular, KEK-B, PEP-II and other high luminosity colliders) but also exploits concepts developed for the damping rings of linear colliders and the latest synchrotron light sources. The luminosity should exceed that of the previous B-factories by nearly two orders of magnitude. It is remarkable, and highly desirable, that the design has enough flexibility, at least on paper, to do so in three different ways. It can also provide record-breaking performance in the tau-charm energy range.

The range of accelerator physics and engineering issues far exceeds what this Committee can review in the time available. However we wish to draw particular attention to the capability of delivering longitudinally polarized beams, the feature that most clearly distinguishes SuperB from the competing Super-KEKB proposal. This has also been approved in Japan and will most likely come online a few years earlier. Unlike previous e^+e^- circular colliders, SuperB design does not depend on the self-polarization of the beams by the Sokolov-Ternov mechanism; rather it relies on a polarized electron source, preservation of the polarization through the injectors and an interaction region design incorporating spin-rotators. The role of depolarizing resonances in the collider ring is diminished by continuous top-up injection of a short lifetime beam. While no entirely similar scheme has ever been operated, one can take encouragement from the successes of the SLC and RHIC in operating with some similar features.

As far as this Committee is aware, the SuperB conceptual design has not yet been subjected to a proper technical review process of the feasibility of its design parameters. This is an essential step which should involve independent experts from the world accelerator community; the credibility of this assessment will require the involvement of experts from all the laboratories which operated the predecessors of SuperB.

The Committee supports the recommendation of the "mini-MAC" that the project now needs a coherent executive management structure. The present conceptual design has been prepared by a broad collaboration of several institutes. However many participants are involved for relatively small fractions of their time. It is clear that some experienced accelerator experts of the LNF Accelerator Division will be part of the core team. However we are concerned that this will constitute a further very serious strain on available resources. No amount of funding and new recruitment will compensate for the lack of renewal of the staff in the Division over many years. Diversion of key staff to SuperB will make it even more difficult than it already is to achieve the DAΦNE performance required for KLOE2 as well as the photon science and other accelerator projects in which the Division is involved.

2.3 ADDITIONAL COMMENTS AND RECOMMENDATIONS

2.3.1 SuperB

At this time many of the comments and recommendations of the Scientific Committee are rather obvious. Nevertheless it seems worth to record them.

- The SuperB and Super KEK B share a rich physics program. The added value of a second collider programme will depend on what is discovered at these colliders and at the LHC, but also on there being no significant delay between the start of data-production of the second collider with respect to the first. The science case for SuperB should be sharpened and discussed in terms of the competition with the Super-KEKB. In this context, the role of delivering longitudinally polarized beams as a potentially unique feature of SuperB should be further investigated.
- In view of the almost inevitable delay of SuperB with respect to Super KEKB, it is crucial that (a) an aggressive schedule be presented as soon as possible, based on realistic assumptions on international participation, available personnel, funding schedule (b) that an appropriate management structure be put in place as soon as possible (c) that the collider design be reviewed as suggested in the preceding section.
- A special concern specific to the LNF environment is that the current human resources in the Accelerator Division are strained to the limit (as already pointed out above) by current commitments to DAΦNE, SuperB and Photon Science. LNF and INFN face the challenge of satisfying all these constraints. A comprehensive plan that addresses all these aspects is urgently needed.
- The SC would like to be informed about progress on the above plans as it gets documented, in advance of its next meeting, if possible.

2.3.2 DAΦNE

The hardware failures and the delays in obtaining replacement components described in the above report make it clear that a carefully thought-out plan of part procurement, maintenance and operation of the collider must be put forward in the immediate future. Indispensable parts of this plan are appropriate funding and the commitment of adequate human resources. These measures appear necessary in order to keep the commitments already made to DAΦNE's experimental program.

The operations of the Beam Test Facility were affected by these hardware problems. Its future role should be part of the management's plan for DAΦNE.

As already pointed out here and elsewhere, this task is made harder by the competition for scarce human resources in the LNF Accelerator Division. Therefore a realistic plan must consider all commitments and requirements, and should probably be endorsed by INFN management at the highest levels.

3. EXPERIMENTS AT DAΦNE

3.1 KLOE DATA ANALYSIS

In the open session KLOE gave a detailed report about the analyses in progress. A few important results already presented at the previous committee meeting as published or submitted for publication were mentioned again. In particular the measurement of the K_S lifetime, to date the most precise available, has now been published.

In kaon physics two analyses are in an advanced stage:

1. the measurement of the branching ratio of $K^+ \to \pi^+\pi^+\pi^-(\gamma)$ which, apart from its intrinsic interest plays an important role in the extraction of the $\pi\pi$ scattering lengths from the cusp analysis in $K^+ \to \pi^+\pi^o\pi^o$.

2. the search for the CP-violating decay $K_S \to 3\pi^o$, for which the whole available statistics is being analyzed (2 fb^{-1} vs. 450 pb^{-1} of the previous, published analysis).

In the analysis of interference phenomena which would allow detecting CPT and Lorentz-symmetry violations new methods and techniques are being applied.

In η physics, after the successful measurement of the Dalitz plot for $\eta \to 3\pi^o$ already presented last year, the KLOE collaboration has submitted for publication the first measurement of the $\eta \to e^+e^-e^+e^-$decay. An analysis of the $\eta \to \pi^+\pi^-\gamma$ decay is in progress and aims at detecting the presence of the contribution due to the box anomaly.

The analysis of the $\gamma\gamma \to$ hadrons processes is in progress and is of interest in particular for the input it can provide to the estimate the hadronic light-by-light contributions to the muon g-2.

A measurement of the ratio of the $e^+e^- \to \pi^+\pi^-\gamma$ to the $e^+e^- \to \mu^+\mu^-\gamma$ cross section, which will provide a further independent check to previous measurements of the hadronic cross section (in view of the insensitivity to many systematic effects) is in a very advanced stage: the results will be presented next month at the HEP-EPS conference in Grenoble.

A precision measurement of the hadronic cross section is crucial in order to obtain the standard model prediction for g-2 of the muon.

KLOE also presented its searches for dark forces signals and preliminary results in excluding regions of the parameter space of models where a light U(1) gauge bosons appears.

3.2 KLOE 2

In the open session, F. Bossi presented the status of KLOE 2 commissioning.

Backgrounds are much higher than expected. Detailed simulations based on GEANT 3 and DAΦNE simulation codes reproduce the shape of backgrounds. Additional shielding will be installed. However it is clear that commissioning is at a very preliminary stage, corresponding to the very small amount of circulating beams provided at this time.

A serious problem has arisen with the KLOE tape library. A large fraction of the tapes became unreadable; at length, the problem was pinpointed to invasion of the tape library by flying insects. Recovery by outside companies is prohibitively expensive; a people-intensive recovery and copying scheme will be implemented.

Some highlights of the Step-1 upgrade were given. The QCALt and CCALt calorimeters are on track to be installed in Spring 2012. The delivery of the clean room for Inner Tracker (IT) assembly was finally delivered on May 30. The vertical insertion tool has been commissioned, and reached the tight (150 μm) tolerance goal on the distance between GEM rings. The IT is planned to be ready for installation, with its electronics, in June 2012.

A "light" shift schedule has been in place since 3 months; about 60 persons are involved in this operation, including 13 from the AMADEUS collaboration.

After the open session, the KLOE referees (G. D'Ambrosio, M. Cavalli-Sforza, G. Colangelo) met with the KLOE 2 team.

T. Akesson had suggested that KLOE show plots of the number of the experiment's milestones vs. time, as declared and as actually reached. The referees received such plots, containing about 30 KLOE (analysis) milestones and as many for the KLOE 2 upgrade; these plots had been presented to CSN1 for 4 years. Only a few delays in the upgrade milestones were observed, mostly due to the delay in delivery of the IT clean room. It appears very likely that all upgrade components will be available by June 2012, as stated above.

It was clarified by KLOE that they wish to stop running and install all the upgrade components as soon as possible once they are ready, because the upgraded detector will make more efficient use of the available luminosity.

In this context, the KLOE experimenters expressed their concerns about the delays of DAΦNE and stressed the need of clearly stated plans, which will need to be closely monitored. As a useful reference, it was pointed out that in the last 3 months of the 2005 run KLOE had accumulated 190 pb^{-1}/month. With the new DAΦNE configuration the goal should be a rate of 400 pb^{-1}/month.

3.3 SIDDHARTA DATA ANALYSIS

The analysis of the kaonic hydrogen data has been completed and submitted for publication (see Ref. [2] in the Appendix). Several other analyses are expected to be finalized in one-half to one year (kaonic deuterium, yields, kaon capture on other elements - like oxygen, carbon - kaon mass, etc.).

The new result on the level shift and width of the 1s atomic state of the K^-p atom is barely consistent with the earlier DEAR result. This is recognized and SIDDHARTA plans to revisit the DEAR analysis in view of the better understanding the collaboration has today of the various backgrounds. If this would lead to a sizeable shift of the published DEAR result this will be announced. The collaboration also will assess the overall agreement of the new SIDDHARTA result and the earlier KEK and DEAR measurements.

Further discussion with the referees of the raw spectrum obtained from the K^-p data resulted in agreement that the results have a significance of about 8σ and that the quality of the overall fit is excellent. The χ^2/DF is ~1 for many degrees of freedom (compared to about 2.8σ for the old DEAR result).

The determination of the kaon mass from the atomic spectra will not be competitive with the present accuracy of PDG results. SIDDHARTA expects to obtain an error 80 keV, to be compared to 13 keV of the PDG. Nevertheless it would be an interesting result because it would demonstrate the feasibility of the method.

The SIDDARTHA collaboration must be congratulated for the successfully carrying out these measurements of the $K^{-}p$ atomic spectra in the challenging environment of the new layout of DAΦNE.

3.4 THE SIDDHARTHA 2 PROPOSAL

The physics case

SIDDHARTA 2 proposes to measure the strong-interaction level shift and width of the 1s atomic state in kaonic deuterium, of order 1 keV, to an accuracy of about 50 eV for the shift and about 150 eV for the width. Together with the 1s level shift and width in kaonic hydrogen, measured by SIDDHARTA at DAFNE, it will enable a reasonably accurate determination of both isospin I=0,1 antikaon-nucleon scattering lengths.

Lattice QCD cannot at present produce this output which is vital input for applying a unitarized chiral approach to kaon-hadronic systems in dense matter. At present there are several indications of K^{-} quasi-bound states in few-body nuclear systems, one of them from FINUDA at DAFNE, giving urgency to precise measurements in kaonic systems.

A fuller more complete physics case for the $K^{-}d$ experiment is given in the appendix, written by A. Gal with contributions from G. Colangelo and from former referee W.Weise.

The proposal

As requested by the scientific committee, the SIDDHARTA collaboration submitted a concise document outlining the proposed detector setup and expected performance improvements to be able to measure the shift and width for kaonic-deuterium ($K^{-}d$) with a 600 pb^{-1} data sample ("SIDDHARTA 2"). The referees were convinced the measurement could indeed be made with an accuracy in the shift of about 50 eV and in the width of about 150 eV, provided the yield and width for $K^{-}d$ do not differ by more than an order of magnitude and factor two, respectively, from the values for kaonic hydrogen ($K^{-}p$).

To proceed the collaboration needs a positive recommendation of the LNF scientific committee for an 8-12 month slot on DAΦNE sometime in the 2012-2015 period (this to be able to obtain funding from INFN, see below). If desirable the collaboration could have the experimental setup ready in the 2nd half of 2012 (*assuming the necessary modifications to DAΦNE, namely the 2nd interaction point, could be made on this time scale as well*). For detector construction they would require additional funds of 300 k€, expected to come jointly from Italy, Austria and Germany. This does not include the costs of the required changes in the DAΦNE interaction point to allow installation (and running) of SIDDHARTA 2. This cost is estimated to be about 300-400 k€.

3.5 AMADEUS

The collaboration continues its analysis of KLOE data.

On this front, progress was severely affected by the problems with the KLOE data tapes – described above - which, for the time being, effectively reduced the accessible data sample from 2.2 fb^{-1} to 0.4 fb^{-1}. Therefore the focus was changed to:

- Development of a more efficient reconstruction algorithm for secondary vertices to notably enhance the $\Lambda \to p\pi$ sample. It looks like the statistics can be doubled, albeit with a slightly reduced mass resolution (still under study);
- study of atomic K^- capture leading to an all neutral final state event topology: $\Sigma\pi^0 \to (\Lambda\gamma)(\gamma\gamma)$ with the subsequent Λ-decay: $\Lambda \to n\pi^0 \to n(\gamma\gamma)$. I.e. a final state with five photons and one neutron. Only charged track handles are the K^+ in the opposite hemisphere and the K^- if the capture occurs in the drift chamber gas (as opposed to in the beam pipe wall). Very encouraging results were shown.

The aim of this analysis is foremost to study the neutron detection efficiency studied a few years ago in the KLONE experiment at Uppsala university.

AMADEUS detector R&D:

A 1-liter GEM-based TPC prototype is under test at PSI and shows already good track measuring performance. Studies of silicon photodiodes (SiPMTs) focused on a better understanding and possibly compensation of the temperature dependence of these devices. Both activities will also have, apart from the eventual AMADEUS experiment, applications elsewhere - like FOPI and/or PANDA at GSI and FAIR, or to SIDDHARTA 2 (SiPMTs). None of this work was deemed to be time critical.

3.6 DISCUSSION AND RECOMMENDATIONS

The SC discussed the future of the DAΦNE physics program in the context of the limited human resources of the Accelerator Division, the recent scenario of frequent collider hardware failures, which has produced at least a one-year delay in physics running, and of the overall situation determined by the approval of the SuperB project.
The DAΦNE physics program cannot be seen as open-ended. In the perspective of its termination, which will be at least partially determined by the shape taken by SuperB plans, urgent measures must be adopted, and priority choices must be made.

Consistently with the recommendations made in Section 2 of this document, the SC recommends that LNF and INFN management urgently devote the funding and the human resources needed to bring back DAΦNE to a performance level allowing it to accomplish the goals of KLOE 2. This includes the specification and implementation of a prudent spare collider component policy, devoting adequate human resources to the commissioning of DAΦNE with the KLOE solenoid and achieving reliable running conditions with a luminosity of about 400 pb^{-1}/month.

On SIDDHARTA 2, the SC considers the proposed measurements a crucial input to several important issues of low-energy QCD and hadronic physics. Nevertheless, in view of the limits on the resources of the Accelerator Division and of the priority to be given to the KLOE 2 physics program, it does not recommend re-installing the second interaction region to concurrently run SIDDHARTA 2. The SC believes that such a program entails technical and schedule risks and would not optimize the overall physics output of DAΦNE. The recommended SIDDHARTA 2 running scenario is one in which this experiment would take data either after the conclusion of KLOE 2 or after the latter experiment has reached an important fraction of its data-taking goals.

4. PHOTON SCIENCE

During the SC meeting, J. Rossbach met with the SPARC project leader M. Ferrario, with the SPARX project leader L. Palumbo and with L. Gizzi of the FLAME team. A number of scientific, technical and management issues related to these projects were covered. The findings are as follows:

4.1 FLAME / PLASMONX

FLAME has made impressive progress in commissioning a state-of-the-art multi-TW laser. They have achieved 50 TW recently and expect to reach the design power of 250 TW by end of July 2011. The beam quality is close to expectations and the beam was successfully focused into a gas cell for laser-plasma acceleration. In the first tests electron energies between 200 and 250 MeV were achieved. in the self-injection mode. This means that the team is now one of the few top players in this field worldwide.

The SC endorses the further strategy as follows:

a) Consolidate the laser commissioning at full power and reproduce the best laser-plasma acceleration results achieved worldwide.

b) Combine the expertise of the laser and accelerator teams. Electron beamlines for Thomson backscattering AND external injection into the plasma bubble are being installed during the 2011 summer shutdown. For autumn 2011, it is planned to begin the backscattering program, generating X-ray pulses of unprecedented intensity. External injection will come in 2013; it needs the design of an interaction chamber. This interaction will also be used for plasma wakefield acceleration driven by a bunch train generated by the laser comb technique which was uniquely developed at SPARC.

   This requires extensive R&D work on the control and synchronization of electron beams on the few femtosecond scale.

The SC acknowledges with pleasure that this is world class work. However the team is acting in a very competitive environment, and needs to keep momentum to get (and later: remain) at the forefront. After all the investment made, the rate of progress is now limited by the available manpower, which consists of five people in the moment, not all of them working full time. In particular, one laser plasma physicist is needed (maybe on the postdoc level). Also funds for laser maintenance (100k€) are needed.

There is potential for international collaborations, e.g. with DESY/Univ. Hamburg, but this requires a reliable funding situation.

4.2 SPARC

Since the Nov. 2010 SC meeting, the SPARC team has continued its successful research program on FEL physics and technology. Highlights include:

- Consolidation of the <u>spectacular results on FEL physics</u> achieved in 2010, such as various modes of advanced FEL operation, SASE FEL operation with tapered undulators, single-spike mode, and several seeding schemes.
- Improved basic understanding of <u>photo-injector physics</u>, leading to electron beam performances comparable with the LCLS/SLAC standards.
- Pioneering work on the generation of <u>trains of two to four bunches</u> closely spaced by only 4 ps, by applying the laser comb technique developed at SPARC. The team demonstrated that they fully control this bunch arrangement in longitudinal phase space (e.g. chirping, over-compression), and showed FEL action of the entire group of bunches, including observation of interference effects.
- Commissioning of a powerful THz source.

All of these achievements are world class and prove that an excellent team has been formed, and that the SPARC team has cutting-edge technology under control.

The personnel situation has been stabilized at very low level. As a consequence, only operation during daytime is possible, and even this not regularly. The most critical issue is probably providing a permanent position to retain an expert on timing and synchronization. Other experts on beam dynamics and machine operation might be lost in the near future, as there are no permanent positions in sight. The Accelerator Division could support SPARC by allocating trained operators on a more regular basis.

SPARC received 300 kEUR in 2011 for hardware and repairs. This was just enough for completion of the new beamline for laser interaction (PLASMONX). Funds are missing for key spare parts, e.g. klystrons.

The SC notes that synchronization is a core element of the PLASMONX program and for many FEL users. Presently the timing jitter between the electron beam and the master clock is on the 150 fs level. This is good enough for entering the external plasma injection research, but it is more than one order of magnitude worse than will eventually be needed.

4.3 SPARX ON THE LNF SITE ("SPARXINO")

The SPARX project has been down-scaled to a 750MeV linac that fits on the LNF site. The SC supports this version. However, as this restricts the minimum wavelengths to some 10 nm in the fundamental harmonic (the water window below 4 nm and even shorter wavelengths will be accessible from higher harmonics), the science case must be re-evaluated. This task needs a reliable, long lasting strategy to get a user community established and motivated.

The SC supports the strategy to extend SPARC into SPARX in terms of beam energy and user program, which may consist of 33% FEL physics, 33% FEL user program, and 33% advanced accelerator concepts (e.g. laser-plasma, Thomson backscattering).

According to a rough estimate, the project needs 25 M€ in construction and parts plus 30 FTE/year times 4 years. Operation requires 20 FTE/year. A detailed resource plan is needed. The funding necessary for user infrastructure should not be underestimated; this might require up to 50% of the total project costs.

To make the machine compact, C-band accelerator technology will be employed for the extension of the SPARC linac. The SPARX team succeeded in fabricating a 50 cm cavity structure which was tested in Japan with impressive success. This technological concept makes LNF also a natural collaborator with world-leading FEL labs like Spring8/Japan and PSI/Switzerland.

4.4 OVERALL ASSESSMENT AND RECOMMENDATIONS

During the last decade, LNF has developed a very powerful, coherent and fruitful scenario of advanced accelerator-based radiation sources resting on three pillars: SPARC, FLAME, SPARX. On the long term, they will rely on each other, because only with SPARX is a reasonable user program foreseen. They should be seen as a unit.

LNF is in a unique situation in terms of laser-plasma acceleration since it is presently the only place in the world where 3 exciting approaches can be pursued and combined: plasma-wakefield with self-injection, external injection of ultra-short, high-energy electron beam, and Thomson-backscattering. This opens up the option for LNF to become and remain a key player in the rich research field comprising full control of electron bunches and photon pulses on the few femtosecond scale. This research program could span at least a decade.

INFN decided to redirect the management of the Italian contributions to international radiation projects like XFEL, EuroFEL, and ELI to Sincrotrone Trieste. INFN may wish to clarify its position with respect to accelerator-based radiation sources because these decisions generated concerns among researchers in the latter field.

The SPARC, SPARX and FLAME experiments put LNF in an excellent position to establish a professorship-level research position, which would further attract young people to the field. Establishing a strong education program on accelerator physics could be a key element in building up an experts team for future LNF accelerator projects. It requires, though, that an adequate number of staff personnel be available and motivated to supervise PhD students.

Regarding plans for DAΦNE after the end of its high-energy physics program, it is suggested to *not* turn it into a dedicated synchrotron radiation source, but to turn it off. This is because the SPARX scenario is much more rewarding.

The SC wants to point out again the importance for LNF to a clear strategy for its future, since priority decisions are needed. Based on this strategy, a project organization plan has to be set up and made public.

APPENDIX: THE SIDDHARTA 2 PHYSICS CASE

Siddharta-2 proposes to measure the strong-interaction level shift and width of the 1s atomic state in kaonic deuterium, of order 1 keV, to an accuracy of order 50 eV for the shift and 150 eV for the width [1]. Together with the 1s level shift and width in kaonic hydrogen, measured recently in DAFNE [2], which provides the most accurate determination of the K^-p scattering length, this will allow to extract the K^-n scattering length, corresponding to the I=1 Kbar-nucleon scattering length, and thereby to obtain the I=0 scattering length $a_0 = 2a_{K^-p} - a_{K^-n}$. Quoting from U.-G. Meissner et al. [3]:

"The necessity to perform measurements of the kaonic deuterium ground state observables is justified by the fact that, unlike the case of pionic atoms, the measurement of only the kaonic hydrogen spectrum does not allow - even in principle - to extract independently both s-wave Kbar-nucleon scattering lengths a_0 and a_1."

Systems with strange quarks are likely to exhibit fundamental QCD aspects. In the hierarchy of quark masses, the strange quark plays an important intermediate role between "light" and "heavy". Precision measurements of kaon threshold interactions thus provide clues to the interplay between spontaneous and explicit chiral symmetry breaking in low-energy QCD.

At present there are no Lattice QCD calculations of antikaon-nucleon scattering lengths, although a theoretical framework has been proposed recently [4], so one has to devise experiments in order to derive these entities. Whereas the K^-p scattering length is directly derivable to a few percent accuracy from the measured 1s level shift and width in kaonic hydrogen, the K^-n scattering length requires the application of multiple scattering techniques to the K^-d scattering length which is derivable, also to a few percent accuracy, from a future measurement of the 1s level shift and width in kaonic deuterium. This application was reviewed in Ref.[5], where its accuracy was estimated as typically 15%, and revisited recently in Ref.[6].

To appreciate the relative importance of this topic to other frontline topics in QCD Hadronic Physics, the review paper Hadronic Atoms in QCD+QED by J. Gasser et al. [7] is very useful. It deals with the π-π and K-π meson-meson systems, and with pionic and kaonic hydrogen, and pionic and kaonic deuterium. Pionic hydrogen and deuterium measurements have been carried out at PSI to accuracy of order 1% for 1s level shifts and a few percent for the 1s level widths [8], providing a test of the applicability of Effective Field Theory and Chiral Perturbation Theory (ChPT) in hadronic systems, and also to pursue the issue of partial restoration of chiral symmetry in dense matter along a proposal first made by Weise [9]. This issue was subsequently resolved by observing deeply bound 1s states in pionic atoms of Sn and Pb isotopes at GSI [10] and by forming a unified description of all the available pionic atom data [11].

Kaonic hydrogen and kaonic deuterium data are vital input for applying Unitarized ChPT, accounting for the subthreshold $\Lambda(1405)$ resonance, to kaon-hadronic systems in dense matter. At present there are several indications of K^- quasibound states in few-body nuclear systems, one from FINUDA at DAFNE [12] and the other from DISTO at SATURNE [13], giving urgency to precise measurements in kaonic systems. For a recent review of physics issues in kaon-nuclear interactions and quasibound states, see [14].

If and once the SIDDHARTA-2 project takes off, several extensions may be discussed and considered.

<u>References</u>

[1] "SIDDHARTA-2 the kaonic deuterium case", submitted to the LNF, Frascati, 14 April 2011, pp. 1-25.

[2] "A new measurement of kaonic hydrogen X rays", M. Bazzi et al. [SIDDHARTA Collaboration], submitted to Phys. Lett. B, arXiv:1105.3090.

[3] "Kaon-nucleon scattering lengths from kaonic deuterium experiments", U.-G. Meissner, U. Raha and A. Rusetsky, Eur. Phys. J. C 47 (2006) 473-480.

[4] "A method to measure the antikaon-nucleon scattering length in lattice QCD", M. Lage, U.-G. Meissner and A. Rusetsky, Phys. Lett. B 681 (2009) 439-443.

[5] "On the scattering length of the K^-d system", A. Gal, Int. J. Mod. Phys. A 22 (2007) 226-233.

[6] "The role of nucleon recoil in low-energy antikaon-deuteron scattering", V. Baru, E. Epelbaum and A. Rusetsky, Eur. Phys. J. A 42 (2009) 111-120.

[7] "Hadronic atoms in QCD + QED", J. Gasser, V.E. Lyubovitskij and A. Rusetsky, Phys. Rep. 456 (2008) 167-251.

[8] "Precision determination of the $d\,\pi \leftrightarrow NN$ transition strength at threshold", Th. Strauch et al., Phys. Rev. Lett. 104 (2010) 142503, and references therein.

[9] "Hadronic excitations and chiral symmetry in nuclear systems", W. Weise, Nucl. Phys. A 690 (2001) 98-109.

[10] "Precision spectroscopy of pionic 1s states of Sn nuclei and evidence for partial restoration of chiral symmetry in the nuclear medium", K. Suzuki et al., Phys. Rev. Lett. 92 (2004) 072302.

[11] "In-medium nuclear interactions of low-energy hadrons", E. Friedman and A. Gal, Phys. Rep. 452 (2007) 89-153.

[12] "Evidence for a kaon bound state K^-pp produced in K^- absorption reactions at rest", M. Agnello et al. (FINUDA Collaboration), Phys. Rev. Lett. 94 (2005) 212303.

[13] "Indication of a deeply bound and compact K^-pp state formed in the $pp \rightarrow p\Lambda K^+$ reaction at 2.85 GeV", T. Yamazaki et al., Phys. Rev. Lett. 104 (2010) 132502.

[14] "Strangeness Nuclear Physics - 2010", A. Gal, Prog. Theor. Phys. Suppl. 186 (2010) 270-281.