41^{st} MEETING OF THE LNF SCIENTIFIC COMMITTEE
FINDINGS AND RECOMMENDATIONS

INTRODUCTION

This meeting of the Scientific Committee is likely to be the last of the directorate of M. Calvetti.
In the open session of 22 November the Director gave an extensive overview of the Laboratory’s status and realizations during his term of office.
On 23 November, in a separate meeting, the Scientific Committee discussed the Director’s report. It warmly congratulates him on the long list of important accomplishments that he was instrumental in initiating or bringing to fruition. An incomplete list includes launching the crab-waist upgrade of DAΦNE, strong support to the world quality photon science program, bringing about the construction of the hadron therapy accelerator CNAO, helping in establishing NA62 at LNF, and involving the lab in CLIC.
More generally, the Committee recognizes that the Director courageously implemented a forward-looking but balanced strategic plan, sometimes facing unfavourable conditions, and deployed considerable management skills in economizing resources and keeping projects on track, all the while displaying a friendly touch and furthering the careers of young people.
Last but not least, the Committee appreciates that the Director never limited its independence in formulating its recommendations. It wishes Director Calvetti a happy and fruitful scientific future after his successful services to the LNF and to our community at large.

In the open session the Committee heard and discussed presentations of photon science activities and of the DAΦNE experimental program, the latter including a summary of the results of the FINUDA collaboration. In the DAΦNE context, a proposal to equip IR2 for collisions with the goal of continuing the program of the SIDDHARTA collaboration was discussed. In the context of the Laboratory's longer-term strategy, a proposal to design and build an energy-upgraded collider, known as DAΦNE_VE for Variable Energy, was presented and discussed. In addition, the status of two ongoing experimental efforts, NAUTILUS and NA62, was presented.

1. PHOTON SCIENCE

Prior to the SC meeting, J. Rossbach communicated with the SPARC project leader M. Ferrario 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:

1.1 FLAME/PLASMONX

FLAME has made impressive progress in commissioning a state-of-the-art multi-TW laser. Very recently, they achieved laser-plasma acceleration in the self-injection mode with electron energy between 200 and 250 MeV. This means that the team is now one of the top few 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 expertise of laser and accelerator teams to realise external injection into the plasma bubble. This requires extensive R&D work on the control and synchronization of electron beams on the few femtosecond scale.

c) Realise Thomson backscattering of FLAME from the SPARC electron beam, generating X-ray pulses of unprecedented intensity.

The SC acknowledges with pleasure that this is world class work. It is understood that the project team is acting in a very competitive scene, and it thus 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. The team urgently needs more staff, in particular one permanent scientist for laser development, one terminated position on laser-plasma-interaction and one dedicated full-time engineer.

For the PLASMONX program (laser-plasma acceleration including self-injection, external injection and Compton backscattering.) even more people will definitely be needed.

1.2 SPARC

Only a little beam time was available since the previous SC meeting, for reasons typical of the summer period, including: lack of air conditioning for the technical infrastructure of SPARC, holidays, time needed for the members of the small team to secure their positions and exams, and technical maintenance. This limited efficiency also reflects the modest staffing situation.

Since November 2010, SPARC has been running for the laser comb experiment.

The plan for December is mainly to consolidate the spectacular results on FEL physics achieved up to mid-July, such as:

- Single-spike FEL operation
- SASE FEL operation with tapered undulator, including first demonstration of generation of a short FEL radiation pulse from a rather long (energy chirped) electron bunch.
- Several seeding results, including seeding by high laser harmonics and cascading down to 40 nm wavelength.

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

The SC acknowledges that the SPARC personnel situation has been stabilized (at a rather low level though) thanks to positions made available for two key people. Positions on electron beam dynamics and synchronization are still critical.

In this context 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 200 fs level and is thus about one order of magnitude larger than needed. Also, because of the staffing situation, SPARC can only be operated during daytime (and even this not regularly), which is rather inadequate for some programs.

1.3 SPARX AND A SPARC UPGRADE SCENARIO ("SPARXINO")

The University of Rome - Tor Vergata has declined to host SPARX on its own land because, according to their opinion, the present energy range of approx. 800 MeV doesn't provide a FEL wavelength range of sufficient scientific interest.

The SC suggests considering seriously a potential alternative strategy, consisting of extension of SPARC at the LNF in terms of both beam energy and user program ("SPARXINO"), and seeking institutional support for this strategy. If upgraded to approximately 800 MeV, a SPARXINO FEL could cover the entire VUV wavelength range into the water window (4 nm and even shorter wavelengths from higher harmonics), and a scientific profile complementary to FERMI/Trieste would be conceivable. Doing this based on C-band linac technology would result in a rather compact linac design, and it would activate expertise already existing in the lab which may also be needed for the DAΦNE upgrade. It would make LNF also a natural collaborator with world leading FEL labs like Spring8/Japan and PSI/Switzerland.

It is strongly advised that the scope of the new facility should not be restricted to technology R&D but should include the spectacular science opportunities offered by this device. To this end, a strong scientific user community should be established, making use of both the brilliant FEL pulses and the powerful Compton backscattering gamma rays, to name but a few. A reasonable application profile might consist of 33% FEL user program, 33% FEL physics R&D, and 33% advanced accelerator concepts such as laser-plasma acceleration and Compton backscattering. In this spirit, the necessary funding for building up adequate user infrastructure should not be underestimated. It might require up to 50% of the total project costs.

Establishing a strong program to attract PhD students to the accelerator R&D seems to be possible and could be a key element in building up a team of experts for future LNF projects, whatever they may be. It requires, though, that an adequate number of staff personnel be available and motivated to supervise these PhD students.

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

2. DAΦNE AND ITS PHYSICS PROGRAM

2.1 DAΦNE UPGRADES

Following the presentations in the open session, J.M. Jowett met with members of the Accelerator Division in the DAΦNE control room to discuss and observe the current status of commissioning.

At the last meeting, it had been anticipated that DAΦNE would by now have been providing luminosity to KLOE, with the new configuration of its interaction region exploiting the crab-waist collision scheme.

Shortly after that meeting, the superconducting solenoid of KLOE was partially warmed-up in order to install the cooling lines for the compensator solenoids. In the following weeks a series of problems occurred with the cryogenic system. Despite the various procedures and attempts to restore normal operation described in the open session, it became clear that there was a persistent helium leak. The consequences appeared potentially serious. An expert involved in the original construction in the mid-1990s was called. Finally, it appears that the leak arose in a very subtle fashion from the thermal cycling of a gasket that had been wrongly mounted in the original installation. There are no apparent concerns for the long-term integrity of the solenoid arising from this incident.

The accumulated delays meant that it was mid-November before the solenoid and compensators were at their operating temperature and the DAΦNE team could commission the proper operational configuration. In the meantime, they had made good use of the time by preparing an optical configuration without the solenoid and embarking on the processes of commissioning and beam conditioning.

Commissioning is now going well and no unexpected problems have been encountered. Measurements of the optics have shown good agreement with the theoretical model and there is good progress towards obtaining the low betatron coupling and flat beams essential for high luminosity. However beam intensities are still moderate and it is not yet possible to say much about the intensity-related effects mentioned in the last report of the Committee.

Follow-up items from the last meeting:

- The shielding of the DAΦNE hall has been upgraded.
- New sextupoles to replace those taken out of the arcs have not been ordered. It was stated that momentum acceptance and tracking calculations showed that they would not be beneficial.
- Electron cloud simulations will start soon.

Comments by J.M. Jowett on the design of DAΦNE_VE are in section 3.2.

2.2 KLOE 2 STARTUP AND FURTHER PLANS

The KLOE referees (T. Akesson, G. D'Ambrosio, M. Cavalli-Sforza) met with the KLOE team on 22 November. A brief report follows.

The KLOE 2 program consists of two phases: Step-0 and Step-1. Step-0 is essentially the original KLOE experiment plus two gamma taggers: the High Energy (electron) Tagger, HET, and the Low Energy (electron) Tagger, LET. In addition the DAQ and data processing have undergone the necessary improvements. In addition, Step-1 has three new detector systems: an Inner Tracker, a forward calorimeter CCALT and a calorimeter around the new quadrupoles, QCALT.

Step-0 is under commissioning. As already described, the cooling of the magnet incurred into significant difficulties, which were eventually overcome. The magnet was cooled down to operating temperature in the week preceding the SC meeting. While these problems were addressed, the DC gas system, the automatic run control and the slow control were commissioned.

The calorimeter is working, and has been calibrated with timing and charge measurements.

The drift chamber is also operational and calibrated, including the R-t relations.

The LET (LYSO crystals read with SiPMs) was installed already at the time of the previous SC meeting, at which time it was decided to put its Front End Electronics (FEE) in an accessible position. The FEE boards are ready and first operation with cosmics took place at the end of October. The responses on MIPs were shown for channels not yet balanced.

The roman pots for the HET were installed already in May 2010. Two test stations with four PMTs and four temperature sensors and standalone DAQ would be inserted in the week following the SC meeting. This will test the insertion procedure, the rates and the temperature monitoring. The scintillators for the final two hodoscopes are fabricated and are to be assembled. The mechanical support for the detectors, electronics and cables are to be the built. The FEE boards are ready, while the rest of the read-out chain is under production or design.

Step-1

The collaboration stressed the excellent collaboration with the accelerator people, manifested in bi-weekly meetings, and the importance that this not be disturbed by assigning additional tasks to the same people. Many issues are being addressed, including the need for cooling at the Inner Tracker (IT) FEE, cable routing decisions and the need for a new insertion system.

The time-critical issue for Step-1 is the construction of the Inner Tracker. Its construction requires twelve months with an aggressive schedule. It has not started yet because the clean room is not yet refurbished, which is expected to take 2-3 months.

In the IT a cross talk problem was found at a connector level. This has been reproduced by simulations, and a solution has been found. It will be verified by the beginning of December.

QCALT: The Module 0 and the final engineering are done. FEE development is ongoing.

CCALT: The final mechanical drawings are completed. CCALT will be ready by the end of 2011. The collaboration has opted for SiPM readout instead of the APDs originally foreseen.

It is worth to report that the collaboration is concerned that an extensive running stop of operations due to IR2 plans may jeopardise its programs.

2.3 KLOE DATA ANALYSIS

There was no discussion on the KLOE 1 analyses; this work is approaching the end. Nevertheless, the referees were informed that:

1. Results on the decay $\eta \rightarrow \pi^0\pi^0\pi^0$ were published in PLB 694(2010)16.
2. A paper on the analysis of $e^+e^- \rightarrow \pi^+\pi^-\gamma$ at $\sqrt{s}$ = 1 GeV was submitted to PLB.
3. A paper on the K_S lifetime was submitted to EPJC.

2.4 SIDDHARTA DATA ANALYSIS

(This section and the following two are based on the discussions of Committee members F. Linde, L. Fayard, A. Gal with a nice mix of juniors/seniors and physicists/engineers from SIDDHARTA and AMADEUS. The committee was pleased to hear that the collaborations continue to attract PhD students, notably from the Rome universities).

SIDDHARTA data analysis is progressing well: first kaonic helium-4 results have already been published and other publications regarding kaonic helium-4 and kaonic helium-3 have been submitted or are about to be submitted. These results solve the controversy arising from reports (by other groups) of possible large level shifts, about 40 eV. Instead, these new results are compatible within errors with shifts of 0 eV and are in good agreement with theoretical predictions.

Kaonic hydrogen data analysis is still preliminary. The values of the transition width and shift reported in meetings is compatible with the latest KEK result and about three times more precise. The committee expects that the SIDDHARTA collaboration will finalize this analysis in the coming months.

The kaonic deuterium results must (regretfully) be regarded as a first exploratory measurement showing a statistically marginal (two sigma) signal. The collaboration is trying to perform combined fits to the kaonic hydrogen and the kaonic deuterium data samples to maximize the sensitivity. Whether or not this will lead to publishable results on kaonic deuterium transitions is still an open question and certainly still requires a substantial amount of work.

The new calibration procedure (which uses roentgen-irradiated foils emitting photons with energies that bracket the relevant photon energies, and is applied about every tenth run during actual data taking) worked very well. The committee compliments the SIDDHARTA collaboration on this achievement which is crucial in calibrating and thereby equalizing the response of the 144 SDDs in the setup.

2.5 SIDDHARTA 2 PROPOSAL

The continuation of the SIDDHARTA experiment (as SIDDHARTA 2) after enabling collisions at IR2 was one of the main issues discussed at this SC meeting.
After the previous (June 2010) meeting, the SIDDHARTA 2 collaboration was explicitly asked to clarify:

- issues related to the DAΦNE machine and the KLOE 2 - SIDDHARTA 2 switchover
- issues related to the Siddharta2 experimental setup.

DAΦNE machine aspects:

The following remarks were contributed by J.M. Jowett:
SIDDHARTA would have to run not only with its own set of permanent-magnet final-focus quadrupoles in IR2, but also those of KLOE in IR1 at their fixed strengths. In comparison with a machine with a single IP, this is likely to result in reduced dynamic aperture, reduced lifetime and larger residual betatron coupling. The possibility of detuning the value of β^* at the KLOE IP (i.e., re-matching with the very limited number of external quadrupoles) should be explored. It should also be checked whether the available sextupole strength in the arcs is sufficient. These studies will help to confirm the luminosity expectations for SIDDHARTA 2.

The following considerations are a summary of the findings from the presentation of M. Preger and discussions with him and with P. Raimondi in the closed session:
Apart from designs and component procurement, which should be completed before interrupting DAΦNE operations, the installation of the IR2 upgrade is expected to take 1 month, and its commissioning is expected to take another 2 months. The opposite change, from IR2 (SIDDHARTA) to IR1 (KLOE)operation requires re-arrangements of the machine components in IR2. This requires 1 month and, in addition, since vacuum has to be broken, about 1-2 months of commissioning. This implies that switches between SIDDHARTA and KLOE data taking, if any, must be kept to a minimum.
Regarding luminosity accumulation rates, at the current time it is expected to achieve the conditions of the last run of SIDDHARTA. This is about 300 pb^{-1}/month delivered of which 150 pb^{-1}/month could be used for physics analyses, because, as in the previous run, data logging during injections is not expected to be practical. Improvements are possible, but cannot be counted on.

SIDDHARTA 2 experimental issues:

A crucial issue is the signal-to-background ratio. By optimizing the gas cell density (which requires extra cooling capacity), the solid angle coverage and the SDD configuration (and cooling) the signal acceptance can be doubled. The background can be reduced by a factor of 20, notably by a much improved kaon trigger layout and the addition of several veto (scintillator) detectors. In addition, a silicon (strip or pixel) detector will be used as an active degrader, replacing the passive degrader hitherto used. Altogether, these modifications should increase the signal-to-background ratio by a stunning factor of 40.

Under these conditions, 600 pb^{-1} should be sufficient to obtain a 20 eV error for on the kaonic deuterium transitions. For comparison with theory, a 40-50 eV uncertainty may be acceptable.

A few additional aspects were discussed:

- Enclosing the full azimuth with SDDs would result in a poorer signal-to-background ratio. Furthermore, it may be difficult to obtain such a large number of SDDs (even if funding were available).

- If the experiment were expanded to measure other kaon-atom systems, the hemisphere under the IR can be used to measure heavier atoms using solid targets instead of gas targets. Also BaF_2 crystals may be installed there to measure photons in the range of 100 MeV.

As to the short-term funding prospects, the referees were happy to hear that a partial funding request to INFN/Gruppo-3 has been granted "sub-judice". These funds could be released subject to a recommendation by the Scientific Committee at its next meeting, in 2011.

First conclusions on SIDDHARTA 2 and scheduling DAΦNE operations.

The Committee agrees that the kaonic deuterium measurement is a scientifically valuable goal, which is worth further investments of resources and of DAΦNE running time. In order to be able to recommend the IR2 upgrade and the approval of a SIDDHARTA 2 run, the Committee requests:

1. that the SIDDHARTA collaboration deliver a document stipulating clearly how to improve the experiment, including a detailed description of the detector modifications, of the resulting improvement in signal and background rates, and of the reasons why 600 pb^{-1} will be sufficient for a good kaonic-deuterium measurement. This new document should be available two months in advance of the next SC meeting, and should focus on the kaonic deuterium program.
2. that the Laboratory management work out scenarios covering the coming years for a program with both KLOE and SIDDHARTA runs, and alternatively a program with only KLOE runs, to make clear what the impact of SIDDHARTA would be on the KLOE operations and its integrated luminosity. These scenarios should be worked out between all the concerned parties: DAΦNE, KLOE and SIDDHARTA, taking into account the appropriate installation and commissioning times.

2.6 AMADEUS

Analysis of previous KLOE data

Most of the time since the June 2010 meeting went into mastering the KLOE Monte Carlo chain. This led to intense collaboration with KLOE colleagues via bi-weekly meetings. The Monte Carlo is now under control, i.e. processes of interest to AMADEUS can be simulated. The event display issue (as suggested in the previous meeting) was followed up. Event displays are now routinely available and turn out to be very useful, for instance in debugging.

Regretfully draft papers have not yet materialized. The collaboration is reluctant to make promises, but it seems that the first publications will be on deeply bound kaonic states like $(K^{-}pp) \rightarrow \Lambda+p$ and $(K^{-}ppn) \rightarrow \Lambda+d$. The next subject might be the Λ mass, provided that the systematics are mastered (currently, there is a 2 eV statistical accuracy and a systematic uncertainty of about 10 eV). This measurement would be very interesting because preliminary results indicate a difference with the PDG value of about 40 eV, i.e., about 3 sigma (the PDG value has a combined accuracy of about 12 eV).

AMADEUS hardware & schedule

The AMADEUS collaboration started discussions with people from IKON with the aim of joining forces. This is welcomed by the Scientific Committee.

The R&D activities briefly outlined below are also supported by EU-funds and foreseen to be used in other setups as well (e.g. at FAIR/GSI).

Trigger hardware studies using scintillating fibres with SiPM readout are ongoing. The aim is to reach a 100 ps time resolution. So far 200-300 ps (in the SIDDHARTA setup) was obtained. If 100 ps turns out to be unattainable the trigger detectors will have to be moved further away from IP, to increase the flight time difference between MIPs and kaons.

R&D is also ongoing on the TPC option with GEM readout.

The schedule of this R&D is not critical because no AMADEUS run is foreseen until the end of KLOE data taking, hence not before 2014.

2.7 FINUDA

The FINUDA Collaboration scientific achievements and in particular the data analysis status were reported by V. Lucherini to the LNF Scientific Committee during the open session.

What follows is an excerpt from the summary of current FINUDA results by referee A. Gal. The full list of results and publications is in the Appendix of this document.

The FINUDA experiment used low energy K^{-} mesons produced at DAΦNE in the decay at rest of ϕ mesons, stopping these K^{-} mesons in nuclear targets and detecting products of various absorption reactions and Λ hypernuclear production and decay processes. FINUDA ran during two periods:

(i) 2003-2004, on targets of ^{6}Li, ^{7}Li, ^{12}C, ^{27}Al and ^{51}V, some of them in multiple settings, with 200 pb^{-1} integrated luminosity;

(ii) 2006-2007, on targets of ^{6}Li, ^{7}Li, ^{9}Be, ^{13}C and ^{16}O, some of them also in multiple settings, with 968 pb^{-1} integrated luminosity.

Results were reported on the following reaction channels:

1. Λ hypernuclear production spectra from measurement of the outgoing pion momentum.

2. Nuclear spectra from measurement of the outgoing pion momentum in Λ hypernuclear mesonic decays.

3. Spectra of protons emitted in Λ hypernuclear nonmesonic decays.

4. Rare, two-body nonmesonic decays of light Λ hypernuclei produced on several p-shell nuclear targets.

5. K^- absorption in light nuclei.

The FINUDA work and results have been extensively reported in major international conferences.

The LNF Scientific Committee is pleased to commend the effectiveness of the FINUDA experimental program at DAFNE and the impact of their results on the current level of understanding of strangeness -1 nuclear systems.

The FINUDA program, in retrospect, kept up a continuity of experimentation in hypernuclear physics at a time when the AGS in Brookhaven and the PS in KEK were out of commission and before J-PARC joined the experimental field. In the last few years almost all world hypernuclear data appeared to come from FINUDA and to a lesser extent from JLAB.

Beyond the significant and systematic new results added to the study of hypernuclei by FINUDA, the FINUDA work on K^- absorption modes in light nuclei was instrumental in establishing a new field of intense research, that of K^- nuclear clusters. It is important to further study and understand these phenomena in the context of dense nuclear matter and of kaon condensation. The Committee thanks the Collaboration for their performance and wishes them continued accomplishments in high-profile future experimental projects.

3. PROPOSAL FOR AN ENERGY UPGRADE OF DAΦNE

The possibility of an e^+e^- collider above DAΦNE energies has been under study in the LNF since the early years of this decade. The DANAE proposal (2006) provided a detailed design of such a machine, and its physics program was part of the KLOE 2 proposal (2006). Progress in collider design – specifically, the beam optics and the crab-waist scheme successfully implemented at DAΦNE – has set a new worldwide standard for these machines and enhances the physics potential of an e^+e^- collider with a CMS energy of 1-3 GeV, the range under consideration in the LNF. In addition, the physics case has become stronger as a result of our improved knowledge of fundamental electroweak parameters.
In the last few months a significant community, representing both accelerator and experimental physicists has launched a design study to specify this new accelerator, its physics program and the detector requirements. The Scientific Committee asked for open sessions presentations of the physics case and of the first ideas on the design of this machine and discussed them in closed session.

3.1 THE PHYSICS CASE

The presentation by F. Bossi focused on the contribution to the measurement of the muon magnetic anomaly $(g\text{-}2)_\mu$ and of the fine structure constant α_{EM} at the mass of the Z. Improvements in the precision of these measurements is required for precision tests of the SM and for full characterization of new physics at current and future facilities.

The hadronic contributions to $(g\text{-}2)_\mu$ currently dominate the error on the theoretical value of this observable. Recent measurements of the cross section of $e^+e^- \rightarrow$ hadrons from several experiments strongly reduced the error below 1 GeV cms and make it imperative to further reduce the error arising from the current uncertainties on the cross section in the 1-2 GeV energy region. A new $(g-2)_{\mu}$ measurement planned at Fermilab should reduce the experimental error by a factor of 4, which strongly motivates a similar improvement of the theoretical calculation, which in turn needs more precise knowledge of this cross section.

The α_{EM} constant is currently the least well-measured of the fundamental constants, due to the uncertainty on the contribution from virtual processes involving the 5 lighter quarks. Again, this correction could be precisely calculated from the measurement below 2.4 GeV.

A fine, high statistics scan of the energy region between 1 and 3 GeV, resulting in a 1% error in the hadronic cross section, would satisfy both of these goals and requires luminosities and running times in a realistic range. The experimental challenge is to achieve sufficiently low systematic errors on a large number of final states.

Other interesting measurements – albeit less fundamental – could be done: among them, the nucleon form factors in the timelike region, $\gamma\gamma \rightarrow$ hadrons processes. More speculative – goals include searches or new physics in the “hidden sector”.

3.2 THE COLLIDER DESIGN STUDY

C. Milardi presented the initial perspectives for a design study of an energy upgraded DAΦNE – type collider. The machine would look rather different from the previous upgrade proposal (DANAE) because it would make use of the state of-the-art available at this time.

Attention is being given to optimally efficient injection schemes. The idea of a small, slow cycling, injector synchrotron inside the DAΦNE ring looks ideal for the top-up injection mode that would be essential for high integrated luminosity. It would simplify injection by eliminating the present accumulator ring. On the other hand, the alternative idea of a C-band linac (constructed in two segments to respect the layout of the present accelerator complex) might benefit from synergies with developments on SPARC.

As a prelude to a full design study by the Accelerator Division, it would be useful to clarify the energy-dependence of luminosity; this could easily be worked out on the basis of available information (parameters of the main magnets) and some plausible assumptions. The difficulties of lower energy operation will be offset by means of the strong wigglers but luminosity will drop off sharply above a certain energy. Within the same exercise, it should also be possible to establish whether there are any prospects for polarized beams (simply by evaluating the Sokolov-Ternov polarization time).

The cost of the project depends strongly on ensuring that the new machine can still fit in the present building while using normal-conducting bending magnets.

The willingness of external institutions to collaborate on the accelerator design is encouraging.

Realisation of the project at a later stage will certainly require earlier recruitment and renewal of expert staff in AD, underlining previously expressed concerns about these matters.

3.3 RECOMMENDATION

In summary, The Committee strongly recommends that the Laboratory move ahead with the DAΦNE_VE design study because:

- The physics program’s focus on accurate measurements of electroweak observables is of fundamental interest.

- The interest shown inside and outside the laboratory, nationally and internationally, testifies to the strength of the program.

- The program is an excellent match to the expertise and the well-established track record of the laboratory, on all fronts, including accelerator, detector and physics analysis expertise.

- This program would keep and further develop at the LNF the vibrant and creative accelerator physics environment that is needed to maintain its leadership position on themes from photon science to ion accelerators.

The Committee strongly recommends that the Laboratory takes the necessary steps to define the main design aspects of DAPHNE_VE, which are necessary for an estimate of costs and schedules.

4. OTHER EXPERIMENTS AT THE LNF

4.1 GRAVITATIONAL WAVE SEARCHES

The spokesperson of the ROG (Ricerca Onde Gravitazionali) collaboration, E.Coccia from University of Roma Tor Vergata, gave a report that mostly dealt with the past and future program of the NAUTILUS gravitational wave antenna. This is a 2.3 ton, 3 m long and 60 cm diameter antenna cooled at 0.1 ºK with a dilution refrigerator, the resonance frequency being around 935 Hz. He quoted the results of the IGEC2 (International Gravitational Events Collaboration) which includes coincidences with other resonant-mass gravitational wave detectors: EXPLORER at CERN which is studied by the same ROG group and also AURIGA and ALLEGRO. A record sensitivity was obtained with NAUTILUS in 2010. Small signals (in agreement with predictions based on the Thermo-Acoustic model) and large signals (in reasonable agreement with the predictions) from cosmic rays have been detected. The latter can be an important background but currently represent a useful tool to verify the wave antenna performance.
The Scientific Committee acknowledges the high quality of the work done and the fact that the wave antennas are in continuous operation, in particular during the periods not covered by the long arm interferometers. The committee notes that the probability of detecting a SN event in our galaxy during this period is not negligible and encourages the collaboration to continue its search in this time frame.

4.2 THE NA62 EXPERIMENT

The NA62 experiment at CERN seeks to measure the very rare decay $K^+ \rightarrow \pi^+\nu\nu$ with high enough statistics to detect possible deviations from the precisely calculated Standard Model prediction (BR = 0.82 10^{-10}, with a 10% uncertainty). Such deviations would point at specific classes of BSM physics.

The experiment will run in a very high intensity unseparated beam and must identify and precisely measure the initial kaon and final pion in this challenging environment, while excluding with extraordinarily high efficiency the presence of particles from all other kaon decays. A large LAV (large angle veto) system of photon detectors is the indispensable requirement and is the responsibility of the LNF group. The group conducted an exhaustive series of test beam experiments to choose the LAV technology and proved that available Pb-Glass counters (obtained from the OPAL experiment at LEP) will perform as needed. The LNF group is responsible for all aspects of the design and construction of the LAV, including mechanics, detector assembly, design and construction of the readout electronics.

The collaboration is also performing a parallel and closely related experiment, known as NA62 –Phase 1. It is the measurement of $R = BR(K_{e2})/BR(K_{\mu 2})$, another small but precisely calculated ratio. Here one may uncover a deviation from the SM prediction which might arise from Higgs doublet structures which are predicted in a large family of models. Data were taken in the future NA62 beam line in 2007 and 2008; with about 40% of the statistics analyzed, R is compatible with the SM. The statistical and systematic errors appear to be small enough to eventually establish relevant limits on popular BSM models.

The Committee considers it scientifically appropriate that the Laboratory invest resources in this experiment. It is conscious that the commitment of INFN to NA62 was instrumental in making its approval possible, and is impressed by the intensity and quality of the work of the LNF group. The SC congratulates it on its efforts.

APPENDIX:
FINUDA RESULTS AND PUBLICATIONS

The FINUDA experiment used low energy K^- mesons produced at DAΦNE in the decay at rest of ϕ mesons, stopping these K^- mesons in nuclear targets and detecting products of various absorption reactions and Λ hypernuclear production and decay processes. FINUDA ran during two periods:

(i) 2003-2004, on targets of ^{6}Li, ^{7}Li, ^{12}C, ^{27}Al and ^{51}V, some of them in multiple settings, with 200 pb^{-1} integrated luminosity;
(ii) 2006-2007, on targets of ^{6}Li, ^{7}Li, ^{9}Be, ^{13}C and ^{16}O, some of them also in multiple settings, with 968 pb^{-1} integrated luminosity.

Results specifically reported were as follows:

1. Λ <u>hypernuclear production spectra</u> from measurement of the outgoing pion momentum in the reaction $K^- + {}^{A}Z \rightarrow \pi^- + {}_{\Lambda}^{A}Z_f$
on several p-shell targets. Capture rates to final Λ hypernuclear states f were determined and the A dependence of the capture process was studied for the first time.

Publications:
M. Agnello et al., PLB 622 (2005) 35 [on ^{12}C target from the 2003-4 run];
PLB submitted, arXiv:1011.2695 (nucl-ex) [on ^{7}Li, ^{9}Be, ^{13}C, ^{16}O targets from the 2006-7 run].
A theoretical companion paper arXiv:1011.2855(nucl-th) used the A dependence of the measured rates to constrain the strength of the K^-- nuclear interaction in the initial state of the hypernuclear production reaction.

2. <u>Nuclear spectra from measurement of the outgoing pion momentum</u> in the mesonic decay ${}_{\Lambda}^{A}Z_{g.s.} \rightarrow {}^{A}(Z+1)_f + \pi^-$ of several p-shell Λ hypernuclei. These spectra, measured for the first time, allowed to decide by strength and shape between normally two possible values of spin for the decaying hypernuclear ground state. In three out of four cases it confirmed earlier knowledge, while for ${}_{\Lambda}^{15}$N it established a spin-parity value of (3/2)+.

Publications:
M. Agnello et al. (FINUDA + A. Gal for theory), PLB 681 (2009) 139.

3. <u>Spectra of protons emitted in the nonmesonic decay</u> ${}_{\Lambda}^{A}Z_{g.s.} \rightarrow {}^{A-2}(Z-1)+p+n$ of several p-shell Λ hypernuclei. A major achievement was the ability to measure proton kinetic energies down to 15 MeV, and this allowed for the first time, in parallel with KEK but using a cleaner method by studying A dependence, to determine the ratio of the poorly understood decay mode $\Lambda np \rightarrow nnp$ to the primary proton-induced nonmesonic decay mode $\Lambda p \rightarrow np$. FINUDA is making use of a 9% detection efficiency to detect also neutrons from nonmesonic decays in order to reduce the errors on the partial decay rates. This analysis is being finalized.

Publications:
M. Agnello et al., NPA 804 (2008) 151;
M. Agnello et al.(FINUDA + G. Garbarino for theory), PLB 685 (2010) 247.

4. Rare, two-body nonmesonic decays of light Λ hypernuclei produced on several p-shell nuclear targets: ${}_{\Lambda}^{4}He \rightarrow dd$, ${}_{\Lambda}^{4}He \rightarrow pt$, ${}_{\Lambda}^{5}He \rightarrow dt$, the latter observed for the first time. Decay yields were established for the first time for all these decays. Hardly any good theory exists for these rare modes.

Publications: M. Agnello et al., PLB submitted, arXiv:1010.5616 (nucl-ex).

5. K^- absorption in light nuclei.
In K^- absorption on ^{6}Li, ^{7}Li, ^{12}C the FINUDA Collaboration observed correlated Λ-p pairs with invariant masses that suggest a deeply quasibound K^--pp cluster. This interpretation has both merits and drawbacks regardless of the theoretical expectation that K^-pp is indeed quasibound [Shevchenko, Gal, Mares, PRL 98 (2007) 082301].
Until earlier this year it was the only experimental PRL published on the subject of nuclear quasibound states of antikaons, which has become a hot topic. Two-, three- and four-nucleon absorption modes in light nuclei were subsequently studied by FINUDA. A comprehensive analysis of various final states through missing mass studies is underway for ^{6}Li target data in order to clarify the origin of the Λ-p invariant mass enhancement.
Another analysis underway is for Σ^- and Σ^+ identification in K^- absorption in several light nuclear targets by observing n $\pi^+\pi^-$ events with one production pion and one decay pion.
The A dependence of the $(\Sigma^-\pi^+)/(\Sigma^+\pi^-)$ ratio shows interesting structure still to be understood.

Publications:
M. Agnello et al., PRL 94 (2005) 212303.
M. Agnello et al., NPA 775 (2006) 35.
M. Agnello et al., PLB 654 (2007) 80 [final-state Λ-d spectrum].
M. Agnello et al., PLB 669 (2008) 229 [final-state Λ-t spectrum].

Topics not reported by Lucherini were
(i) a search for neutron-rich Λ hypernuclei ${}_{\Lambda}^{6}H$ and ${}_{\Lambda}^{7}H$ in the (K^-, π^+) reaction [PLB 640 (2006) 145], and
(ii) a limit on (K^+, K^o) charge exchange in ^{7}Li very close to threshold [PLB 649 (2007) 25].