Frascati, January 21, 1993

Note: **G-16**

DAΦNE PROJECT REVIEW

Frascati, January 19-20, 1993

Reviewers

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Project Schedule

We have noted the very good progress made with the scientific and technical decisions that had to be taken during the past 6 months. All the points raised at the last Review have been seriously tackled and most of them clarified. The overall project progress looks impressively good.

The Review Committee regrets that the extension of ADONE operation, already envisaged at the last Review, has introduced a four month shift in some of the starting dates, and that this has in reality resulted in a delay of 6 months in the availability of the buildings.

We also noted that excessive delays have appeared in the procedure needed to place the contracts. This is an extremely important part of the Project and the internal procedures have to be rectified with the utmost urgency, especially in view of the heavy purchasing activity to come in 1993.

DAΦNE Lattice

Linear Optics:

The committee took note of the excellent work which has been performed on the optimization of the linear optics. The new approach of matching the straight sections to an unmodified optics of the arc allows the optics of the arcs to be frozen now. In the opinion of the committee, this is important in order to continue with the detailed design of the very complex components of the arcs and move forward with placing orders.

The interchangeability of the insertions, between commissioning optics and the optics of the straight section with experiments, seems to be essential in order to reach the high performance of the lattice. The Rotation Frame Method solves the problem of finding appropriate compensation for the solenoid coupling. The remote control foreseen for rotation of the low beta quadrupole triplets and/or electromagnetic skew trimming quadrupoles to allow for corrections after implementation of the experiments, is considered to be important.

The detailed layout of the interaction regions should be the main priority of the optics group in the next few months and should be presented at the next Review.

Nonlinear Optics:

The tracking results with random multipole errors for the main magnets (done for the old lattice, and which now will be repeated for the new lattice) show a sufficiently large dynamic aperture, even for ±1% momentum deviation. Multipole components from sextupoles up to decapoles for the bending magnets and quadrupoles, and an additional 20-pole term for the quadrupoles has been included. The Committee feels that at least one calculation should also be performed including gradient errors (which need to be larger than the feed-down quadrupole terms of the residual orbit errors, if orbit distortions are to be neglected). This is the dominant effect in aperture reduction for lattices with high periodicity. Even though the symmetry is lower for the DAΦNE optics, a break of the linear symmetry will introduce additional resonances caused by sextupoles.

Simulations performed with the solenoids revealed that the stable horizontal amplitude is much larger than that due only to multipole errors. The vertical reductions on the other hand are comparable. Therefore, it is recommended that calculations also be performed with both effects (solenoids and multipole errors) included. The off momentum behavior is considered to be especially important, since the solenoid compensation is imperfect, as was mentioned in the presentation of this topic. At a later stage, the committee would also like to see the long-range effects of parasitic crossings included in the tracking calculations.

The Experiments for DAΦNE

The Committee finds it very useful to be informed on the status of the preparation for experiments as part of the Machine Review. Especially in a collider like DAΦNE the experiments will be strongly integrated into the machine structure.

It was noted that a second experiment is under active consideration for future approval.

As a result of the latest (final) proposal for the main ring optics, the experimental solenoids and their associated local compensation elements (compensating solenoids and rotated quadrupoles) will form two insertions matched to the rest of the machine. DAΦNE will not be able to operate with one (or both) experimental solenoids switched off. The only alternative will be removal of the inactive experiment and replacement with the commissioning insertion (which will be used for the initial running in of the machine).

This situation has obvious repercussions on the reliability required for the experimental apparatus and on the future operating and maintenance cycles of machine and experiments.

The status of KLOE was presented and the progress made in the conceptual design was noted. The collaboration, after consultation with a group of experts, has decided to adopt a superconducting solenoid. It is envisaged to have a total of six superconducting solenoids (one main solenoid and two compensators per experiment).

The concept of pre-assembling the experiment in a dedicated hall and then moving it into the beam position looks fine.

The details of the interaction region where machine components and the detector share the same space are being studied. It is apparent that this will be a complicated and difficult region to design and build. We noted that the detector and machine groups have started an exchange of requirements in this shared region and we encourage this dialog to continue as the details of the Interaction Region design are being hammered out.

Alignment

The choice of the rotation frame method to partially compensate the effects of the detector solenoid seems a good idea. Precious space is saved by rotating the final focus triplets and using them to initiate the compensation of the solenoid. This means that the final focus triplets become part of the detector. In order to tune the triplets, it has been suggested that some form of mechanical adjustability be installed to do this. We feel that mechanical adjustments will be difficult to implement in this area where space is at a premium and therefore should be minimized. We recommend that, whenever possible, electrical adjustments be made instead (e.g. the strength of the solenoidal field could be adjusted to match the global rotation angle of the triplets).

Detector motion through ground settlement is also a problem when precisely aligned machine components are inside the detector. The position of the detector should be monitored regularly. It may be necessary to realign the detector to keep it properly positioned. This possibility should be taken into consideration when the detector supports are designed.

The maximum range of movement of the support system for the final focus triplets (at present 1mm) must be specified in conjunction with the experimental groups as it is determined by the positioning accuracy of the detector.

Backgrounds

It appears that synchrotron radiation as a detector background is not a problem. The critical energy of the arc magnets is 210 eV and this radiation will not get closer to the Interaction Point than the splitter magnets about ± 5 m from the Interaction Point. The splitter magnets produce synchrotron radiation with a critical energy of 29 eV which means that only 3×10^{-17} of the produced photons are above 1 keV.

Beam-gas interactions as a detector background needs to be investigated. The source of these particles that produce backgrounds in the detector needs to be found and a special effort made to improve the vacuum at these sources. It is not clear, at the present, that there is a need for a very high vacuum in the detector beam pipe.

Because the critical energy of the synchrotron radiation in the detector region is so low (29 eV from the splitter magnets and still lower for the triplets) it is possible that the assumed value of η (1×10^{-6} molecules/photon) is incorrect for this region and may even be lower. We recommend that a measurement of η be made for this low critical energy radiation.

Detector Beam Pipe

An inner sleeve that minimizes HOM loss at the Interaction Point appears to be necessary. The thickness of this sleeve needs to be kept to a minimum for physics reasons, yet must be designed to tolerate heating due to I^2R losses in the material. We recommend that coatings of higher conductivity metals be investigated to minimize the heating. In addition, we suggest looking into composite materials and structures to keep the amount of material to a minimum.

The Committee would like a presentation of the entire Interaction Region at the next Review.

Control System

The Control System has three levels. The first level contains the consoles for the control room (and elsewhere) which will be Macintosh double-screen computers. These run the high level code which will contain most of the accelerator physics theory and which is accessible either through the operator interface or as a stand alone application. These consoles communicate with the second level via a VME 32 channel parallel bit highway and traffic is organized by a polling system.

The second level is the centre of the "Star" configuration and contains the communications manager and the Real Time Data Base. It consists of VME crates with many sets of DEVIL/OPLA/Memory cards. The DEVIL, a VME board containing Macintosh LC logic (68030 CPU, 4 MByte RAM, Macintosh RAM) as well as the links to Ethernet, VME and VSB, has been designed at Frascati. The Committee was pleased to see that the first commercial prototypes have now arrived and are performing well. OPLA contains the optical link and a first prototype is already in house being evaluated. The hardware of the second level (and the third level uses similar hardware) seems to be in good shape.

The third level also consists of VME crates containing sets of DEVIL/OPLA/Memory boards. These cards take care of the interface and local control of the hardware. Communication with the second level is via dedicated bi-directional optical links.

The Committee does not foresee a problem with the speed of the third level, nor with the connection to the second level. The speed of the VME bus used to interconnect the crates in the second level (64 Mbit/s) is more problematic. This bus could become a bottleneck if there are many processes running which require information to be shared between different crates on the third level (e.g. feedback loops). It may well be that it will be necessary to create secondary "Star" networks to control geographically separate parts of the machine (e.g. the transfer lines, the accumulator, the main ring injection system, etc.). A detailed evaluation of the network traffic is needed to decide this.

The number of consoles also needs to be determined as well as the number of processes that will be running simultaneously and needing information from lower levels. This will determine whether the VME link between levels one and two (20 Mbit/s) is sufficiently fast.

The management of files to ensure that the database is up to date and consistent accross the three levels of the control system deserves careful evaluation. File corruption is a major problem with large control systems with distributed processing and tools must be provided for network diagnosis during machine operation. It will also be necessary to implement some form of database history and operations logging.

The most pressing priority for the Control System appears to be a detailed analysis of the operational requirements of DAΦNE. For the next Review, the Committee would like a presentation of the following topics:

1) A detailed breakdown of the number of devices to be controlled and the number of control points per device.

2) This list should also contain a complete list of instruments required with the expected update speed.

3) Since ADONE will be closing down, it would be advisable to create a Commissioning and Operations Group for DAΦNE which should prepare a plan for how the accelerator complex will be run. Especial emphasis should be given to the number of consoles required in the control room and elsewhere and the number of feedback loops that may be needed (including the update speed required). This group should also create an Alarm system hierarchy to avoid flooding the control system with useless messages.

This information should provide the input necessary for the Controls Group to:

1) Prepare a description of the control system configuration (rather than the general architecture) including the number and location of the different elements.

2) Make an estimate of the time needed to execute some standard operations, breaking down the operation into time spent at the different levels and the various communication delays.

   a) Change the setting of a magnet.

   b) A feedback system which measures and corrects an orbit.

   c) Measurement and correction of the machine tune.

3) Examine the list of controls programs of FermiLab prepared by Rolland Johnson (which was provided by the Committee) and evaluate what fraction of these programs are relevant to DAΦNE. The controls group should then try and estimate the manpower necessary to produce software which performs similar functions for DAΦNE.

If all of these steps can be carried out by the next Review, the Committee believes that the Control System would be close to being able to make a cost estimate and schedule and to start placing orders for equipment soon after.

Main Ring Vacuum System

The Committee was pleased to see the very good progress made on the vacuum system in general and on the mechanical design of the vacuum chambers in the four quadrants of the two rings. The pumping requirements and resulting pressure profiles have been evaluated from the expected out-gassing rate based on measurements and after a reasonable dose of beam cleaning.

The present proposal, taking into account the interferences between the two rings and leaving access for work on both rings, looks good and convincing. The delivery, at the end of February, of a full scale prototype of a 2 m section of the dipole vacuum chamber is welcome.

However, a review of the different arc vacuum chambers and of their fabrication should be made in order to minimize the number of different designs (presently 8). Particularly, the adoption of a similar pumping port for the sublimation pump and the ion pump on the dipole vacuum chamber should be seriously envisaged, thus reducing to 4 the different necessary vacuum chambers.

The fabrication of the vacuum chamber in two symmetric pieces, welded together in a process specified to minimize deformations is recommended; this reduces mechanical deformations during operation.

Very promising performance of the sublimation pump has already been measured in the vacuum test laboratory. The pump has been shown to meet the pumping speed requirements during an acceptable operation period of 1 week at full current before regeneration by Titanium evaporation. The continuation of the tests are encouraged to optimize the Titanium evaporation process, thickness and roughness as well as to calculate the necessary number of filaments, their possible number of regenerations and their lifetime.

The results of the tests on the prototype of the vacuum chamber and sublimation pump will have to be evaluated at the next Review before the Committee can endorse the choice of the complementary pumping scheme using both Ion and Titanium Sublimation pumps. Moreover, the possible interaction of the magnetic fields of the dipole magnet and the ion pump which are in close proximity will have to be carefully checked.

The design of the Photon Absorbers has progressed very well since the last Review. They are now independent of the vacuum chamber structure with direct cooling by water but no interface between water and vacuum. The material choice in Aluminium or Copper has still to be made after construction of prototypes including water cooling. A copper design is, *a priori*, recommended for better thermal conductivity and lower gas desorption.

Ion Trapping

A detailed model of the beam potential distribution all along the ring has been presented demonstrating that reasonable electric fields from localized electrodes are effective in clearing ions from the electron beam. The study of an overall clearing system is now recommended, defining the number and the positions of the various electrodes and the necessary potential on each electrode. Resonant clearing should not be excluded since it greatly reduces the voltage requirements. Ion trapping in the wiggler will have to be carefully simulated in order to analyze the clearing efficiency and to define the vacuum requirements in this critical zone. Finally the equilibrium ion build-up and clearing due to the rather widely spread electrodes should be derived for various vacuum pressures.

In parallel, a mechanical study of the possible implementation of clearing electrodes in the vacuum chamber, optimizing the design for a low beam impedance, should be prepared for presentation at the next Review. The electrode design in use at EPA at CERN should be investigated.

The conditions of self clearing by reduction of the emittance coupling should also be investigated. Is the corresponding transverse coupling practically achievable with an acceptable Touscheck lifetime?

Mechanical Calculations

The Committee was pleased to see that the DAΦNE group has now the capability of making detailed ANSIS engineering calculations in house. The modeling of the main arc vacuum chamber shows a relatively small (300 μm) deflection of the chamber which appears acceptable.

The study of the kicker magnet is more difficult and, while the Committee agreed that the excitation bars are most probably not a problem, we would recommend extending the study to include modifying the bar thickness slightly to shift one of the natural frequencies in resonance with the 50 Hz excitation. This would enable a better understanding of the possible amplification factors (in the presence of damping) to be determined.

DAΦNE Kickers

There has been considerable progress on the design of the kicker magnets since the last review. A first prototype has been studied and an industrial prototype is undergoing acceptance tests at the vendor.

The detailed improvements, aimed at reducing the impedance, have been successful and the Committee is confident of the basic design. Final optimization of the pulser system should continue with the aim of minimizing the voltage needed.

A long duration run should be undertaken in the next few months to gain information about reliability, as the kickers are usually a major source of downtime.

Beam Instabilities and Broad-Band Impedance

The Committee was impressed by the excellent work done on beam instabilities and modelling the beam impedance. A serious effort has already been invested in the reduction of parasitic impedance and a nearly complete impedance budget has been presented. The addition of all small contributions of numerous elements like clearing electrodes, beam position monitors or instrumentation tanks is recommended.

The new overall broad band impedance estimation (below 1Ω) makes the single bunch instability thresholds well above the operational current with a comfortable safety factor. The dependence of the impedance with the bunch length would be appreciated.

The multibunch instabilities are still the most severe problem. The Committee recommends continuing the combined effort of higher order mode damping in the cavity and development of the feedback system which should stabilize the beam, at least in the 30 bunch mode. Possible higher order modes in other elements like the kickers, septa or instrumentation tanks should be carefully investigated and damped as much as possible.

RF System

Since the last Project Review, a large effort has been spent into the design of the RF system. The Committee is pleased to see that the contract for the Accumulator Cavity has been awarded, as planned. Concerning the Main Ring cavities, an extensive comparison between cavity shapes (rounded and with nose-cones) has been done. The R/Q values of the various modes, their damping factors and the total HOM power have been evaluated in the two cases. It turns out that the results are very similar, and therefore the decision on which cavity type is selected, will be made on engineering (mechanical design, cooling) considerations. The choice of a rounded cavity seems very likely and the Committee would support such a decision which, we understand, will be made very soon.

The low level prototype to be ordered in the near future (February 93) will allow precise measurements on the exact HOM frequencies and their sensitivity to, for instance, tuner settings. A better estimate of the total HOM power and its distribution over the various modes should then become available.

There will be no full size cavity prototype for DAΦNE with which high RF power and vacuum tests can be performed. The tendering procedure to be started in Spring 93 will be for the two operational cavities of the Main Ring. In this situation, the Committee believes that sufficient flexibility should be included in the cavity design, so that unexpected behavior with high RF field in vacuum, could be corrected at the expense of small modifications of some cavity elements. In this respect it would be very useful to collect information on the behavior of the cavity with waveguide damping, which is to be tested at KEK for their B-Factory project. Similarly, early delivery of the first cavity would be important to make full RF power tests as early as possible.

Damping of the HOM's with loops has shown some very promising results which looked comparable to the waveguide damping. This approach should be evaluated in more detail, possibly with selective dampers combined with broad band devices (waveguides or loops). For waveguide dampers, the preferred solution is with a broad band wave-guide to coaxial transition and a load outside vacuum. The Committee supports this choice and encourages further study. Even though the estimated HOM power, even with missing bunches, does not seem to exceed the kW range, it would be very useful to measure the actual HOM power during machine operations and its spectrum on the external load.

Feedback System

There has been considerable progress with the different aspects of the feedback system. A completely new simulation program has been written which is already giving convincing results. Good agreement with the analytical theory was demonstrated. A careful comparison with the code developed at SLAC should be undertaken with the object of identifying and eliminating any inconsistencies.

Now that the feedback hardware design has been specified in collaboration with SLAC, effort should be concentrated on building prototypes of all parts of the system which are special to DAΦNE (pick up's etc.) as well as choosing and specifying the exact configuration that will be installed at DAΦNE. This will enable a cost estimate and schedule to be established. Work on the electronics prototype should continue at Frascati to ensure that the group gains familiarity with the hardware.

The DAΦNE group should continue the collaboration with the SLAC/LBL group and participate in the test of the prototype at the ALS.

Conclusion

The Project Team has made great progress in understanding the scientific and technical problems of the machine over the last six months. The emphasis of the Project is now starting to shift towards detailed engineering and placing orders. In 1993, 45% of the total Project budget should be spent.

The Committee has evaluated and endorsed the updated Project Schedule and Milestones presented by the Project Leader. It will take a dedicated effort on the part of the entire project team (theoreticians, scientists, engineers and administration) if this tight schedule is to be kept.

The next Reviews will take place as follows:

5th Review will be held during the week of July 12 - 16, 1993.

6th Review will be held during the week of January 10-14, 1994.

The Agenda of the 5th Review should include presentations on:

- The Interaction Region
- Beam Instrumentation
- The Control System
- The RF System
- The Status of Project Engineering.

PRINCIPAL DAΦNE PROJECT MILESTONES

Mar 93	**MAIN RINGS OPTICS FROZEN**
Apr 93	**MAIN RINGS RF CAVITY SHAPE DEFINED**
Aug 93	**ADONE DECOMMISSIONING COMPLETE BEGIN CONVENTIONAL CONSTRUCTION** - requires contracts awarded and ready to go (May 1 and Sep 1)
Jan 94	**BEGIN INSTALLATION OF LINAC** - requires beneficial occupancy of Linac building
May 94	**BEGIN INSTALLATION OF ACCUMULATOR**
Dec 94	**LINAC OPERATIONAL**
Feb 95	**BEGIN INSTALLATION OF MAIN RINGS** - requires beneficial occupancy of DAΦNE hall
Apr 95	**BEGIN ACCUMULATOR COMMISSIONING**
Dec 95	**PROJECT CONSTRUCTION COMPLETE** **BEGIN MAIN RINGS COMMISSIONING**