DAΦNE TECHNICAL NOTE

INFN - LNF, Accelerator Division

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DAΦNE PROJECT REVIEW

Frascati, February 20-21, 1995

Reviewers

F. Bonaudi (INFN-Torino)
D. Boussard (CERN)
G. Brianti (CERN)
J.-P. Delahaye (CERN)
A. Hutton (CEBAF), Chairman

Project Overview

The Laboratory Director started the meeting by announcing the bad news of a delay in the bending magnet procurement for the DAΦNE main rings of at least nine months (this is discussed later).

Apart from the magnet delays, the project has accumulated several other worrying scheduling problems. The commissioning of the linac which was expected to begin by Christmas 94 has now shifted to Easter 95. While the construction and installation of the accumulator ring still appears to be on schedule, it appears unlikely that the beam can be transported to it on the planned timetable due to delays in the transport magnets. The civil engineering of the KLOE assembly hall is behind schedule, delaying access to the DAΦNE Hall and there appear to be doubts as to whether the Cryogenics plant will be operational by the time it is required for mapping the detector magnets.

The Committee is genuinely concerned that it will take a considerable amount of effort to place the remaining contracts, follow up the existing contracts and avoid major installation conflicts and that this will detract from the effort that will be required at the same time to prepare and execute the commissioning of the linac and accumulator.

The Committee feels that it is extremely important to have a schedule and a plan of action for the Project at all times. Given the delivery uncertainties, this schedule will require frequent modifications. Nevertheless, a coherent plan, even if it has errors is extremely valuable as it enables priorities to be re-evaluated quickly when problems occur.

At the 7th Machine Review, the Laboratory Director was asked to examine the global schedule for the start up of DAΦNE, including the criteria that both machine and detectors should achieve prior to bringing the detectors into DAΦNE. The topic was brought to the LNF Scientific Committee who proposed the criterion that each detector should demonstrate full performance with cosmic rays according to the design before being considered ready for installation in DAΦNE. As a corollary, the Machine Advisory Committee proposes that the machine should demonstrate 30% of the design single-bunch luminosity with the 'Day 1" optics before installation of an experiment.

It is the strong preference of the Project Leader that the two detectors be brought into DAΦNE one at a time, with a period of machine commissioning in between rather than both at once. The Committee felt that there was no need to take a decision at this time.

At the last meeting, the Committee had requested a presentation of the global machine commissioning scenario at this meeting. This request had been pre-empted by the magnet delivery problems. The Committee feels strongly that this topic must be addressed at the next meeting and that the question of series or parallel installation of the detectors should be part of this global planning.

Magnet Delivery

The construction and delivery of the magnets for the main ring and for the transfer lines are the responsibility of the same contractor (Ansaldo). A considerable delay in the delivery schedule has become evident (6 to 10 months) in all the contracts placed with this vendor. At present, the few laminations already cut for both the dipoles and the quadrupoles are out of tolerance and cannot be accepted. Both the construction of the dies and the stamping operations were delegated to subcontractors and it is now urgent to conduct a thorough technical investigation of the technical specifications received by the subcontractors.

Recommendation 1

LNF must obtain access to the full technical content of these sub-contracts and of the order for the steel. In particular, the steel quality, the dimensions of the dies, the stamping procedure (one or two stamping operations) should be assessed on the basis of the current experience of other projects. Urgent correcting actions should be undertaken by the contractor in close consultation with LNF.

Recommendation 2

Assuming that these faults will be corrected with urgency, the Committee recommends that the Project should have a representative at Ansaldo during all the prototype construction and at least the initial phases of production. LNF should send this representative, who must have an adequate technical background and be independent from Ansaldo, as soon as possible. It is recognised that the Project leader does not currently have such a person available but the task is so crucial to the Project that some creative solution must be found.

Finally, while it is correct to focus the attention on the magnets of the main ring now, attention should be paid also to the construction and delivery of at least the first magnets for the transfer lines, specifically those which transfer the beam from the Linac to the Accumulator Ring. allowing the commissioning of the Accumulator. Their construction schedule should be reviewed vis-à-vis of some of the main ring magnets in order to allow the Accumulator to be commissioned well ahead of the main ring.

Measurement of the Accumulator Magnets

Measuring procedures and evaluation of the results show a state-of-the-art competence of the staff involved and the results obtained so far are quite satisfactory. However it is recommended to continue to improve the multipolar content of the dipoles (mainly decapoles).

Status of Experiments

As requested by the Committee at the 7th Machine Review, the status of the two experiments was presented. Besides covering more specifically the problem of installation and interfacing with the machine, these reports gave an overall view of the advancement in the design and construction of the detectors as a whole.

FINUDA

There now exists a design for the magnet iron yoke and end caps and for the superconducting coil, to be built by Ansaldo. The calculation of the magnetic fringe field shows a result acceptable to the machine. The cryogenic supply characteristics have been defined and fit in with and overall scheme covering also KLOE and the 4 compensating solenoids.

A transport scenario has been studied, including the move into the DAΦNE Hall and pit. At present it is foreseen to perform the cold tests and the mapping of the field on the manufacturer's premises.

The study of the inner mechanical structure carrying the detectors and the insertion quadrupoles has made good progress and the present design looks convincing. The operation of inserting the cylindrical vacuum chamber prior to moving into the beam should be studied in detail. It is foreseen to align the axis of the experiment to the machine axis to within ± 0.1 mm.

A mechanism for the removal of the inner parts of the detector (e.g. to replace the nuclear target layer) is under study to minimise the disturbance to the rest of the apparatus.

An overall schedule was presented, proposing to have the detector ready for beam in Autumn 1996.

KLOE

The construction of the superconducting solenoid will now be carried out as a collaboration Elin-Oxford Instruments. The iron yoke will be supplied by INNSE (Milano). The magnetic field will be mapped at Frascati (using the same machine as OPAL, ZEUS and FINUDA): duration foreseen is 2 months. The move of the experiment into the DAΦNE Hall, the insertion of the detector elements and the final alignment onto the beam line have been analysed in some detail by means of a model. The definition and design of the detector components has made much progress; procurement and construction (calorimeter) are under way. The overall schedule indicates that the cryoplant would be needed by June 1996.

The detailed study of all aspects of installation and operation, including the interfacing with the machine, should continue, together with the ordering of the necessary specialised equipment. The present version of the schedule indicates that KLOE could be ready at the beginning of 1997.

Machine Backgrounds

The background due to particles lost in the detector region due to the Touschek effect was evaluated. Plausible position for scrapers were identified and the particle losses in the detector region were studied as a function of the scraper position. The loss rates are about four times worse for the FINUDA detector than for the KLOE detector but for now, neither detector group seemed unduly concerned by the absolute value of the losses. The effect of the scrapers on both the loss rates and the Touschek lifetime was investigated.

The reduction in lifetime seemed a high price to pay to reduce the loss rates if the background levels are already acceptable to the detectors. The Committee recommends continuing the study to find out the fraction of particles that are lost in the detector region that actually end up in the detector active volume and create background. In this study, the particles of energy slightly above the beam energy should be evaluated separately from particles with energy slightly below the beam energy as the loss mechanism is somewhat different. If the background levels are deemed acceptable due to a low conversion rate, the scrapers may not need to be installed initially.

The Committee also recommends examining the injection process to ensure that particles from a badly set-up injection do not get lost in the detector region.

RF System

The RF power amplifier of the Accumulator Ring has been delivered and tested recently up to 50 kW on a dummy load, largely exceeding the requirements. This, together with the successful tests of the low power electronics and controls, means that everything is ready in the laboratory to commission the RF cavity. The latter is still with the manufacturer due to difficulties in obtaining the central part without porosities (the cavity is made out of a special hardened copper, for which long term experience was not available). A solution has finally been found and electron beam welding of the central part is going to take place next month. Complete testing of the RF system of the Accumulator Ring is expected by end-spring 1995.

As for the Accumulator Ring, the RF cavity of the main ring is the crucial item of the system. Pre-machining of the cavity is completed and electron beam welding of the flanges is expected in the next weeks. Power tests should take place in Summer, after the Accumulator Ring RF cavity tests are completed.

Compared to the expectations of the last Machine Committee, testing of the 150 kW klystron has been delayed, due to the non-availability of the cooling infrastructure. The acceptance test is now in progress.

As far as cavity ancillaries are concerned, the Committee is impressed by the very good results obtained with the high order mode couplers, including waveguide transitions, feedthroughs and attenuators. For the main coupler the Committee suggests additional diagnostics in the window area (local vacuum gauge, arc detectors in vacuum, etc.), and recommends careful control and assembly of the individual parts.

Additional simulation results on cavity damping have been presented to the Committee. They should be compared to previous results as well as to experimental data, in particular for the weakly damped trapped dipole mode. The damping of this mode should also be re-evaluated including the other holes in the cavity for the main coupler and tuners. These holes will most likely increase the coupling of the mode to the waveguides.

Vacuum System

The Vacuum System in general has made excellent progress. Orders for major elements have been placed: namely the vacuum chambers for the arcs and their supports, some of the vacuum chambers for the straight sections, the round beam position monitors, the Helicoflex gaskets and the nitrogen generator.

All VAT valves have already been delivered as well as the ion pumps for the transfer lines and accumulator.

The machining of the aluminium plates for the first two full size arc vacuum chambers has been realised very satisfactorily. The final cleaning and polishing by chemical detergent without alcohol is impressive and the welding of the upper and lower part will follow soon. The production of the 4 arc chambers for the positron ring is therefore well under way for delivery before the end of the year according to schedule. The choice of the heater and insulation will be confirmed after intensive bake out tests on the first vacuum chamber.

The design of the two kinds of clearing electrodes to equip the arc vacuum chambers of the electron ring has been presented. Some prototypes have been successfully tested under high voltage and thermal stress during bake out. Nevertheless, the Committee is particularly concerned about the behaviour of these electrodes (1.2 m and 2 m long) inside a vacuum chamber with very difficult access. It recommends a review of the guiding and connection of the electrodes and would encourage seeking a solution where the electrodes are not designed to slide in their supports due to difference of dilatation during bake out. Also, the electrodes will resonantly couple to the beam if the length is harmonically related to the bunch separation. The low frequency voltage induced by the beam in these conditions should be carefully evaluated. Finally the question was raised of the sensitivity of the ion trapping to the difference of bunch population.

A prototype of the synchrotron radiation absorber has been tested at full power (1.5 kW). A long duration lifetime test should now been prepared, after connection of the absorber to the arc vacuum chamber, simulating the numerous thermal cycles due to temperature changes during beam storage.

The design of sublimation pumps has now been finalised with an excellent pumping speed and lifetime. They are equipped with six double standard Titanium filaments sufficient for 1 year of operation at full current.

Finally, the pressure profile all round the rings at full current after 200 Ampere hours of conditioning has been presented and looks satisfactory with an average pressure of the order of 10^{-9} torr as specified. It remains to check if the corresponding background in the sensitive region of the detectors is acceptable.

Interaction Regions

A program of technological tests on Beryllium tubes (brazed and welded joints) is under way at two external firms/institutes. It is not possible yet to draw conclusions on the feasibility of the more exotic shapes, such as the spherical bulb and inner thin shield for KLOE. At the time of the next Review a decision should be taken as to whether to start a back-up program to build a simpler chamber.

The supporting scheme for the permanent magnet quadrupoles of the two experiments is under design. The cantilever support for the inner quadrupoles of KLOE may present a structural problem.

The FINUDA quadrupoles will be mounted inside a tube fitting within the cylindrical housing which forms part of the detector structure.

The adjustment mechanism of the innermost quadrupoles with 5 degrees of freedom, already presented at the 7th Review, was discussed; it was stressed that the adjustment of the upstream and downstream parts must be constrained, to guarantee co-linearity of the whole. The procedures for the initial mechanical alignment of the quadrupoles and for subsequent checks with beam should be studied in detail. The Committee was worried that the beam-based alignment did not permit a sufficient number of independent measurements to constrain the 10 degrees of freedom available.

Beam-Beam Incoherent Resonances

The Committee was (again) impressed by the quality of the work done by M. Biagini and M. Zobov on beam-beam incoherent resonances. Beam blow-up caused by the interaction between machine resonances and the beam-beam effect as presented both analytically and by tracking analysis is very convincing.

The new recommended tunes ($\nu_x = 5.13$; $\nu_y = 6.10$), which provide an improved lifetime and reduced beam blow-up without substantial reduction of the dynamic acceptance, is well supported by the Committee.

In order to check the validity of the model and of the tracking program, it is suggested that a similar analysis be made on an existing colliding ring (LEP for example), comparing the simulation with the beam experiments. If the model is as good as it appears to be, it could be valuable elsewhere.

Longitudinal Feedback

The joint development of the feedback electronics is going extremely well. A prototype system has worked successfully at the ALS in Berkeley, stabilizing up to 137 bunches. The limit in this case is the power available in the final amplifier stage feeding the strip-line kicker cavity. Tests are expected to resume in March. The final, modular electronics system is now operational using pre-production prototypes and is undergoing tests at SLAC. The software required was also reported to be well advanced.

The Committee has been favourably impressed by the work presented on a new kicker cavity for the longitudinal feedback which requires half the power for the same kick. This solution looks far more attractive than the original strip-line design. It is almost completely calculable, including the higher order modes of the structure, and in addition it offers a higher sensitivity for a comparable bandwidth and has less than half the beam impedance. The decision to go ahead with this solution looks straightforward to the Committee. Simulations of the overall damping of the feedback system, including realistic bandwidth limitations have been presented, and convinced the Committee of the validity of the new design.

Conclusion

The Committee is extremely concerned about the schedule delays in several areas of the Project which will require additional effort to resolve. This will negatively impact the preparations for commissioning the accumulator and later the main rings. Most of the problems that were brought up during the Review were caused by factors outside the direct control of the Project Leader and his staff. The Committee strongly urges the Laboratory Director and the Project Leader to work together to try and find a creative short-term solution to the manpower shortage created by the lack of responsiveness of some of the contractors.

The Committee continues to be extremely impressed by the quality and quantity of work performed by the Project Team who are now tackling physics and engineering issues that have never been addressed elsewhere. It is a pleasure to see the Frascati group emerging again as a world leader in the accelerator field.

The next Review will take place as follows:

9th Review will be held on 3-4 October, 1995

The Agenda of the 9th Review should include presentations on:

- Global Installation Plan
- Global Commissioning Plan
- Linac Commissioning Results
- Detailed Accumulator commissioning plans.

DAΦNE PROJECT

PRINCIPAL MILESTONES

SEP 95 **LINAC OPERATIONAL**

DEC 95 **ACCUM. OPERATIONAL**

DEC 96 **BEGIN MAIN RINGS COMMISSIONING**

WE ARE AWARE THAT THERE IS LITTLE CONTINGENCY.

REASONS FOR ADDITIONAL DELAY ARE:

1) **MAIN RINGS MAGNETS**

2) **PROCUREMENT PHASE START-UP**

3) **TECHNICAL PROBLEMS**