DAΦNE TECHNICAL NOTE

INFN - LNF, Accelerator Division

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DAΦNE PROJECT REVIEW

Frascati, October 3-4, 1995

Reviewers

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

Introduction

The Project Leader, Gaetano Vignola, opened the meeting by expressing his thanks to the outgoing Laboratory Director, Enzo Iarocci, for his strong support during the previous years. The Committee would like to echo this sentiment. The members have had frequent, and always positive interactions with Enzo during the course of the project and have always been impressed by his vision and clarity of purpose. Enzo has surely established a high standard for his successor.

Machine Status

In the eight months since the last Review there have been a number of very visible and impressive achievements. The Linac has been delivered, installed, checked out and beam has been successfully brought to the positron target. The Accumulator Ring mechanical components have been delivered and positioned in the hall and the transfer line magnets between the Linac and accumulator are also in place. The civil construction has advanced with the DAΦNE Hall near completion and the KLOE building to come in about five months.

The first articles of all of the DAΦNE components are already in house or under test at the factory and in many cases delivery is complete. Of particular note is the first vacuum chamber successfully produced and accepted while production of the RF cavities is well advanced (the accumulator RF cavity is already installed and has undergone system testing at full power with the production amplifier).

The Project Leader informed the Committee that a proposal for a third experiment, DEAR, had been received, and that it would be discussed at the LNF Scientific Committee in October. The Committee felt that the proposal would not negatively impact the machine commissioning or the other two experiments and, if the LNF-SC approves the proposal, believes that integrating this kind of experiment into the machine would not require changes either in the commissioning strategy or in the schedule.

The only major technical (and schedule) problem remaining is the main ring dipole magnet. The first prototype was of low quality and required in-house machining of the poles and the ends in order to meet specifications. An improved stacking method has been proposed which should lead to acceptable magnets. Nevertheless, the Project must maintain close control over production.

Against the backdrop of many successful accomplishments, it is clear to the Committee that virtually every scheduled due date has slipped, many seriously. The commissioning of the accumulator will be impacted by the delay in providing utilities caused, in part, by delays in the civil construction. It is almost certain that there will be a similar delay in the DAΦNE main rings. The Committee found that in every case, the Project Team had responded rapidly and appropriately within the limits of the staff available, but the lack of manpower becomes more and more apparent.

In virtually every accelerator project in the world, this is the time when temporary staff are hired to ensure that momentum can be maintained and that problems can be dealt with promptly. The Committee reiterates its recommendation to the Project Leader and the Laboratory Director to work together to explore every possible option for providing increased manpower during this critical phase of the project. It is the conviction of the Committee that without additional support, the delays will be compounded, despite the best efforts of the Project Team.

Schedule

Even with additional manpower, the installation needs to be scheduled in detail, with every member of the project team intimately aware of it, and the strategy being followed. This will enable the inevitable difficulties to be worked around rapidly without losing too much time. Without this, it is clear that different activities will interfere and create crises at a time when the work most requires careful attention to detail. One of the most important jobs of the Project Leader will be to provide the overall installation strategy, ensuring that first the Accumulator and then the Main Rings are properly checked out prior to injecting beam (hot check out of components, check of individual computer controls and finally, system integration checks).

Status of FINUDA

The winding of the superconducting coil has started at the manufacturer (Ansaldo). Other components (cryostat, impregnation vessel, iron yoke) are under fabrication. It is confirmed that the whole magnet will be tested and measured at the manufacturer before shipping. The transport will consist of two heavy (ca. 140 t each) loads, i. e. central yoke with the coil in it, and the end caps. Shipping to Frascati is foreseen for the Autumn of 1996. The transit of the magnet across the DAΦNE hall must be looked at in detail, in order to minimize the disturbance to the machine.

The "clepsydra" support of the inner detector is under fabrication, including insulating joints to limit eddy currents during coil quenches. It is foreseen to pre-assemble all detector components (except the outer scintillator hodoscope, Tofone) on the "clepsydra" and then insert this into the magnet. The handling robot to assemble the inner parts of the detector is still under design. The various detector components are all on order, with several items already available. The assembling of the straw tubes will begin at Frascati the next month. The radial clearance between the Be vacuum chamber and the inner scintillator cylinder (Tofino) has caused some concern (it is now 3 mm). This should be evaluated as part of the general design of the interaction region.

Status of KLOE

Shortly after the previous Machine Review, the magnet yoke had to be retendered because of a dramatic increase in the world price of steel. The new schedule now foresees assembly of the iron at Frascati by September 1996.

The fabrication of the coil at Oxford Instruments has also run into problems because of the bad quality of the coil support cylinder which had been ordered previously by the original vendor. Oxford Instruments has decided to start again from scratch (a wise choice) and the new cylinder is now being designed. The termination date for the coil is presently scheduled to be completed by December 1996. If this schedule is maintained, the magnet could be ready at Frascati (tested and measured) by mid July 1997.

The components of the detector are all under fabrication: 50% of the central calorimeter modules have been built. The clean room and special tooling for stringing the track chamber are ready. So as to make the best use of the time made available by the delay in the magnet, it has been decided to assemble together the track chamber and the calorimeter in order to run and debug them as a system.

The installation of the whole experiment in the machine pit is now foreseen for late 1997.

LINAC Status

The Committee was impressed by the quality of the Linac fabrication and installation by Titan Beta, completed nearly on schedule and executed very professionally. The commissioning has already started, with the first beam brought to the 200 MeV point in May. The cavity phasing was under way during the Review and RF conditioning should be completed in October 1995. The electron beam commissioning will follow in November and it is foreseen to complete the positron beam commissioning by February 1996.

Although the Linac commissioning is under the responsibility of Titan Beta, the Committee is pleased to see that LNF personnel is collaborating closely with the Titan Beta installation and commissioning team. This is indeed an excellent strategy, and provides a unique opportunity for the future operations group to gain experience with the Linac operation and be well prepared to take over after Linac acceptance.

In spite of the tough schedule, the Committee is confident that the specified beam performance can be met before March 1996 when the beam must be available for the start of the accumulator commissioning. The Committee recommends that the Linac be operated as much as possible during this period in order to test equipment reliability and improve the beam availability: a necessary condition for efficient beam commissioning of the rest of the complex.

In particular, the Committee recommends that the Linac test area should be made operational as soon as possible next year, in parallel to completing the beam delivery to the Accumulator. This will be useful not only to get experience with Linac operation but also to test equipment, instrumentation and parts of detectors. This will also provide an opportunity to develop and improve the procedures that will be required to switch rapidly between different operating conditions.

Accumulator and Transfer Lines

The mechanical installation of the Electron/Positron Accumulator is near completion. The magnets have been aligned to within ±0.5 mm, the orientation of the ring with respect to the global net has been verified. The magnetic components and the vacuum chambers are of good quality and all of the installation work is very clean and professional. The EPA manufacturer, Oxford Instruments, should be commended. The RF cavity has already been fully tested and is in place. The ring vacuum chamber can be closed after one of the stripline kickers is repaired as it was damaged during the shipment. The final magnet alignment is now being carried out by trained DAΦNE staff under the guidance of F. Sgamma. The cabling and cooling water system are to be completed by March, 1996. The acceptance test will follow and then the first injection can begin.

The transfer line components are on hand. More than half of the line between the Linac and the EPA are in place. The electron and positron branches between the "Y" magnet and the EPA injection points were pre-assembled to check the interferences and then removed to facilitate the installation of EPA. These two branches will be installed some time this month. Ansaldo is the vendor for the transfer line contract; they are very much behind the contractual schedule and the workmanship of the components is only marginally acceptable.

The Committee is concerned that the schedule for installation of the utilities and cabling is out of phase with respect to the turn on of both the transfer lines and EPA. The Committee was pleased to see that Andrea Ghigo has been appointed to be responsible for the Accumulator installation, but he must be fully supported by the Project Leader and the INFN/LNF administration to forge ahead with the contractual procedures. It is strongly recommended that a critical-path method schedule be prepared, and then followed by all parties concerned. Every effort must be made to turn on the whole injector system by the beginning of March 1996. The DAΦNE staff must have sufficient time to commission the individual parts of the injector complex and to gain experience in operating the whole system before the main ring commissioning begins.

Interaction regions

The communication between the interested parties (machine physicists and engineers and the two experimental groups) seems lacking. Two years is a very short time to design and produce two such complicated systems. The DAΦNE Project Leader should appoint a person officially to oversee these two regions. A firm requirement list should be worked out and be used as the basis for scheduling all the tasks to be performed. A regularly scheduled weekly or bi-weekly integration meeting should be constituted to monitor the progress and discuss technical issues. The requirement list should not be altered without official approval from the Project Leader.

The progress in developing the Beryllium vacuum chamber is very slow. The responsible engineer should take a more active role by communicating directly with the Russian vendor on the technical aspects of the program; going through K-TEK of USA takes too much time. The most critical part of the KLOE Interaction Region chamber is the RF shield and there has been no progress during the last six months. K-TEK seems confused as to the shape requirement of this shield. It would be a good idea to fabricate a full size aluminum alloy shield (with a thickness of ~1 mm) and give it to the fabricator as a visual guide. It is suggested that LNF establish an additional development contract with K-TEK to develop a full size shield prototype to prove the feasibility of such a design.

There is still no vacuum chamber layout for either interaction region. The mechanical engineering group should proceed to collect all the available information and to transform them into an official document for discussion among the interested parties, including the detector groups.

Aster Enterprises has made good progress in producing the permanent magnet Low Beta quadrupoles. The Project Team is urged to continue this good collaboration with them. The trim coil package residing in the Q_D and Q_{F2} have not been worked on, and even the requirements do not seem to be properly specified. They are rather difficult attachments to these magnets, requiring careful mechanical and cooling design, so the Committee urges the Project Team to proceed with this task very soon. The Low Beta quadrupole support tube and the mechanical adjustment devices have also not been worked on. Due to the obvious lack of manpower, it is suggested that this task be performed by an outside contractor.

RF and Feedback

The Committee was pleased to see the RF cavity of the Accumulator now in place after successful power tests in the Laboratory. It is reassuring that the conditioning of the cavity went so quickly up to full power (250 kV accelerating field) without evidence of any multipactor discharge. Satisfactory results have been obtained for pre-tuning the cavity at the factory, tuner operation under power, and successful testing of the control electronics. The only problem, a broken circulator, is fortunately not on the critical path, as the cavity can be powered directly from the Rhode & Schwarz power generator.

The Committee feels that installation of the power amplifier, the RF feeder line and the final control electronics in the Accumulator should be completed well before the availability of cooling water, irrespective of the status of the circulator. Testing the Accumulator RF should start immediately after cooling water becomes available.

Progress on the main ring RF cavity and klystron looks satisfactory from the technical point of view, despite some delays with respect to the expectations of last February. The Committee looks forward to seeing the complete cavity, including the higher mode couplers and loads at the next meeting.

Feedback and Timing

Work on the back end of the longitudinal feedback is progressing satisfactorily (both the feedback cavity and the electronics). The spectacular results obtained on the ALS machine validate the choice of the SLAC DSP technology. The same people are also involved in general instrumentation especially for the Accumulator Ring. The Committee feels that this should be given priority now in view of the startup of the machine next Spring.

The fast timing is essential for the initial operation of the Accumulator. The performance of the circuits developed for that purpose is satisfactory; however, the Committee strongly felt the need for a complete integration of these modules into a coherent timing system (software and hardware) under a clearly established responsible person.

Vacuum System

The vacuum system has continued to make good progress. The completion and delivery of the first arc chamber, including the successful acceptance testing, and the progress of the work on the other arc chambers is an excellent achievement for such an important system. The delivery schedule for the remaining seven chamber is satisfactory.

The design of the support system makes it possible to install the vacuum chambers in the DAΦNE hall independently from the magnets. This should be done as soon as possible, provided that they are adequately protected during other installation work. This should be a part of a revised installation strategy and detailed schedule. The problem of storage of the chambers prior to installation in the hall also needs to be addressed.

There are two versions of the RF-shielded bellows being studied at the present time. The in-house design uses undulating strips without sliding action while the VAT design uses RF fingers with sliding contacts. Each has its pros and cons, the Project Team is urged to proceed with both approaches until such time as a clear winner emerges.

A satisfactory solution has been found for the clearing electrodes and the design of all other components has been finalized. On the whole, the status of the vacuum system seems to be very satisfactory and is not expected to be on the critical path.

Optics up-date

The recommendation for modification of the transverse tunes closer to the integer or half integer is fully endorsed by the Committee. Well away from beam-beam driven resonances, the new tunes not only improve the luminosity but also significantly increase the dynamic aperture which is finally comfortably larger than the vacuum chamber dimensions. Moreover the larger momentum compaction factor is very favorable for beam instability thresholds.

One side effect is that the dispersion in the injection straight section is no longer zero. This is perfectly acceptable given the low energy spread of the beam delivered by the Accumulator, and is even useful for additional sextupoles which improve the chromaticity correction.

The only drawback of these new tunes is the reduction of the beam life-time by Touschek effect because of the reduced momentum acceptance an inherent byproduct of having a larger momentum compaction factor. This could be compensated, if necessary, by control of the bunch length through a third harmonic cavity for which a pre-study has already been presented.

The demonstrated flexibility of the lattice is very much appreciated, and opens the possibility of exploring a large tune area by simple tuning of the quadrupole strengths. Both proposed tunes (5. 09/6. 07 and 4. 53/6. 06) are very attractive for dynamic aperture and beam-beam effect.

The half-integer tune seems to present additional advantages, being far away from sextupolar resonances as well as from the integer resonance which facilitates closed orbit correction, and far from the main diagonal ($\nu_x = \nu_y$) which could perturb the control of the coupling between transverse planes.

The KLOE and FINUDA optics should now be matched to the new tunes. The central quadrupole at the Interaction Point of the day-one optics is certainly very useful to reduce the chromaticity and facilitate the start-up. It could possibly be removed in a second phase of commissioning once the single beam optics has been well studied to free this zone for additional instrumentation for colliding beam studies and/or possible detectors like DEAR.

Beam-Beam Interaction

The study of beam-beam interaction profited greatly from the visit of K. Hirata from KEK. His numerical simulation program was installed and is now available to the laboratory for further studies. Many results of this program were presented, together with an analytical model to confirm the trends seen in the simulation.

The results confirmed the necessity to move the tunes closes to the integer and half integer to give smaller beam-beam tune shifts and to be further away from beam-beam driven resonances.

Two possible tunes have been proposed which not only improve the luminosity during collisions but also the background by significantly reducing the maximum horizontal and vertical amplitude of the particles, as well as limiting the growth of the tails.

Weak-strong simulations shows that good luminosity can be obtained in both interaction regions simultaneously without a significant reduction of luminosity. The same simulations showed that the previously adopted tunes were unacceptable from this point of view. Further investigations are necessary to explore possible strong-strong beam-beam effects in the case of two different interaction point configurations and unequal phase advances between the two interaction points.

The Committee is delighted that the new tunes have been shown to be close to optimum for both the single beam effects and also the beam-beam effect. This is a major step forward and the Committee would like to congratulate the Project Team on this accomplishment.

The accelerator theory group should now concentrate its efforts on completing the high-level software packages required for commissioning and operating the accelerators.

Longitudinal Beam Dynamics

The new value of the momentum compaction factor looks very attractive for the overall machine performance. Detailed studies of bunch lengthening show that the onset of turbulence is much higher with the new value $\alpha_c = 0.02$. The only unfortunate result is that the bunch length is too short, even in the case presented of 127 keV RF accelerating voltage.

This study should be repeated for the maximum accelerating voltage of 250 kV (required for Touschek lifetime) to better assess the need for a third harmonic cavity. It must be remembered that the construction time of such an object is at least one year and in view of this, it is recommended that the evaluation of the need for the third harmonic cavity proceed rapidly to allow time for design and procurement.

Beam Instrumentation

The Committee asked for a presentation of the status of the overall Beam Instrumentation which was not on the Agenda. Mario Serio showed a list of fourteen different instrumentation types and a total of 214 systems. Given the extremely small group involved in developing the instrumentation, this is an impressively complicated list.

The mechanical part of the instruments seemed to be in good shape, as did some of the current monitors recuperated from ADONE. Some of the electronics was sufficiently standard that it can be directly ordered from industry.

The Committee remained worried about the degree of preparation of the electronics for the beam position monitors. Specifically, the instrumentation for the initial beam commissioning of the Accumulator is in serious jeopardy and may require that the commissioning be performed with reduced capability. A similar scheduling problem can also be foreseen for the Main Rings.

The Committee strongly urges that every effort be made to ensure that the maximum amount of instrumentation is available for the initial commissioning. In addition, it would be extremely useful to everyone if there were a complete, updated list of the status of the instrumentation at any given time to enable the Project Leader to provide back-up resources when possible to facilitate placing of orders etc.

Conclusion

The Committee is pleased with the positive progress made but is extremely worried by the amount of delay that has already been accumulated, and the likelihood that the present schedule will slip due to lack of resources. The next few months should be spent trying to expand the number of people working and in focusing on pre-commissioning of the hardware so that commissioning with beam can focus on the problems inherent to the beam rather than using the beam to find hardware problems.

It is also vital that the strategy for the commissioning be laid out by the Project Leader and that every member of the Project Team is working towards the same priorities. The Committee has again requested that this strategy be presented at the next meeting. However, the real beneficiaries of a clearly defined strategy and a easily accessible schedule is first and foremost the Project Team.

The Committee appreciates the enormous effort that is being expended by the whole Project Team and feels that they have every reason to be proud of the visible accomplishments to date. The Committee encourages the Project Leader to ensure that sufficient additional support be provided to ensure that the present rate of progress is at least maintained in the next phase of the Project when many things will simultaneously require rapid attention.

Finally, the Committee recommends that the Project Team adopt the goal of obtaining circulating beam in the Accumulator by the next EPAC in June 1996. A European accelerator conference is the best place to showcase the quality of the results already achieved and this would be reinforced if beam were already circulating in the Accumulator Ring and the beam characteristics were measured.

The next Review will take place as follows:

10th Review will be held on April 16-17, 1996

The Agenda of the 10th Review should include presentations on:

- Global Installation Strategy and Schedule
- Global Commissioning Strategy and Plan
- Detailed Accumulator Pre-Commissioning Results, including first Operational Experience of the Control System
- Detailed Accumulator Commissioning Plans
- Main Ring Pre-Commissioning and Commissioning Strategy
- Interaction Region Layout.

DAΦNE PROJECT

PRINCIPAL MILESTONES

DEC 95 LINAC Operational (e^+ @ 550 MeV)

MAR 96 BEGIN ACCUMULATOR COMMISSIONING

DEC 96 MAIN RINGS INSTALLATION COMPLETE

(Magnets delivered within July 96)