DAΦNE TECHNICAL NOTE
INFN - LNF, Accelerator Division

Frascati, April 24, 1997
Note: **G-47**

DAΦNE PROJECT REVIEW

Frascati, April 22-23, 1997

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Introduction

The Committee is delighted by the progress in the Project which is obvious to even the most casual observer. Everywhere, things are in high gear with world class results from the Linac and the Accumulator, and installation of equipment in the DAΦNE Hall proceeding in a structured, organized effort. Everyone who has contributed can be justifiably proud of the state of the Project.

The Committee listened to a series of excellent presentations of results but, perhaps more importantly, was shown a series of internal reports where these results had been documented, analysed, and made available for later use. This insistence on evaluating results is a rare occurrence in a Project that is pushing hard to complete construction but is a practice that will be of enormous value to everyone later.

Completion of the installation, and preparations for commissioning of the DAΦNE machine are now rightly at top priority. The need for close collaboration with the experiments has become more pressing and this trend will certainly increase over the coming months.

DAΦNE Linac Commissioning

The Committee congratulates the team in charge of the Linac commissioning for the excellent results achieved. In addition to the commissioning of electron operation which was already demonstrated last year, almost nominal performance with positrons has now been achieved: 31 mA of e^+ at 535 MeV within an rms momentum spread of 1% and an e^- to e^+ conversion efficiency of 7.6%/GeV. It is specially remarkable that not only was this performance reached in a very short amount of time (18 days of e^+ operation) but also that it could be achieved by the INFN staff without any help from SLAC or Titan-Beta experts. This is the most effective way to train and learn about the Linac systems, tuning and operation.

An overall check and fine tuning of the RF system was also performed, raising the modulators to their nominal voltage of 310 kV, repairing and tuning the SLED RF pulse compressors, demonstrating an excellent reliability during an 18 hours "hot run" operation at full power and nominal repetition frequency of 50 Hz, and showing a remarkable agreement between RF power measurements and corresponding beam energy. The reliability of the klystron could be improved following a procedure established in close collaboration with the Thomson experts. The provision of sufficient spares is foreseen during the year.

The nominal beam energy of 510 MeV is now exceeded with both electron and positron beams at a reasonable klystron power operation.

The Linac was used for 28 days as an injector for commissioning of the Accumulator with electrons and, although not fully optimised, demonstrated beam performance well above the specifications (in particular a maximum beam current of 1 A, the specification being 150 mA).

Finally, even if some cleaning-up has still to be made, like setting-up of the optimum temperature of the Accelerating Structures and systematic measurement of beam characteristics (emittance, momentum spread), the Linac is now considered fully operational for both electrons and positrons. As a consequence, the Linac has been accepted from the Titan-Beta Company at the end of February '97.

Accumulator Commissioning

The Committee acknowledged the excellent progress obtained from the last Review on the Accumulator. The commissioning with electrons is now fully completed with very good performance reached already: up to 218 mA stored in single bunch, 250 mA in three bunches and 180 mA in eight bunch operation, limited by longitudinal instabilities, with a reasonable injection efficiency of 65% and 100% capture efficiency. A substantial beam dose of 2.8 Amp·hours has been accumulated, which helped to increase the beam lifetime up to 108 min. at vanishing current by beam cleaning of the vacuum chamber.

A number of basic optics measurements have been performed with beam (tunes, chromaticity, dispersion function) and the measurements compared well with the modeling of the Accumulator. This model has been used on line with the Control System to correct the closed orbit in both planes to within less than 1 mm and precisely to determine the absolute positions of the beam position monitors.

Very interesting beam dynamics and collective effects were already measured and compared with theoretical predictions, like the variation of synchrotron phase and bunch length with the charge per bunch. The study of bunch instabilities which limit the performance has started.

Finally the complex timing system for a (virtual) injection in the main ring up to the maximum number of 120 bunches has been demonstrated.

Now that almost nominal performance with positrons is available from the Linac, the commissioning of the Accumulator with positrons is foreseen in the coming weeks, as soon as the Control Room is available. The Committee is worried that only one week is presently foreseen for the operation of the Accumulator until September. It recommends that enough time be devoted to the completion of the Accumulator commissioning in order to be fully ready for the start-up of DAΦNE in September not only for positron operation but also for the study and improvement of the operation with multi-bunch as well as for a good training of the operators. By the time DAΦNE commissioning begins, the Linac and Accumulator complex should be fully in the hands of the Operations Group to free up the accelerator physicists to concentrate on DAΦNE.

Main Ring Installation Update

Concerning the Main Rings, it is very satisfactory to see that practically all the components are now in house and that impressive progress has been made in the installation of major sectors of the rings.

The Committee is impressed by:

1) The organisation of the work by C. Biscari and F. Sgamma;

2) The excellent documentation presented in terms of completeness and the precise time schedule for the remaining work.

The visit confirmed the impression that the layout of utilities is well thought-out in the crammed region of the rings which will facilitate maintenance and repair.

In addition to the machine itself, the installation and commissioning of the cryogenic plant and of all other utilities for the experiments is progressing satisfactorily.

The forecast that the installation will be completed by summer, so that the commissioning with beam can start in September, is completely plausible.

Other Mechanical Components:

1. Non sliding bellows - The spacer between the conducting strips has been modified from mechanical to welded joints as suggested during the last Review. This will improve the heat transfer characteristics and the operational reliability.

2. Straight section bellows - Some of the electro-formed copper bellows appear to have various degrees of oxidation. Any accidental venting in the future will no doubt increase the oxidation. A suitable protective coating would be helpful in this respect.

3. Titanium Sublimation Pump filaments - There are too many bolted joints in this assembly. Heating and cooling of the filaments may cause the joint to become loose. It would be better if number of the bolted joints can be reduced by using welding joints.

Few Comments On Installation:

1. Precise alignment of mating end flanges prior to inserting the non sliding bellows is essential.

2. Clearance between the chambers and other components should be carefully checked to assure the proper allowance for expansion during bake out cycle.

3. Proper flushing of the newly completed processed water system is mandatory before being connected to the magnet system.

4. The bellows connections should be made in a clean enclosure at their designated locations. Flowing of dry Nitrogen gas during connecting operation should be done so that there will be no eddy flow created between the flanges. The eddy currents can bring undesirable water vapor into the chamber interior.

Radio Frequency System

During the commissioning of the Accumulator, the RF cavity, its 50 kW tetrode amplifier and low level circuitry behaved extremely well: no power supply faults were recorded, tolerances on field stability were all met. The Committee is pleased to see that full computer control of the whole system will become available very soon. For the Main Ring, this will be true already at the beginning of operation of the RF system.

As far as the Main Ring RF system is concerned, installation and testing of one cavity and two klystron amplifiers is proceeding smoothly, without surprises. The second cavity, which is now assembled in the test hall should be power tested very soon, using a 50 kW tetrode amplifier. Broad band cavities, amplifiers and circulators for the longitudinal feedback are all delivered and are being tested and adjusted. Initial results are in agreement with expectations.

The Committee was impressed by the spectacular experimental accelerator physics results achieved in a very short time with the Accumulator and its RF cavity. The imaginary part of the machine impedance is related to bunch lengthening, which was measured. The measurements and expectations from the estimated machine impedance are in spectacular agreement, giving much confidence in the numerically calculated bunch wake field and in the low frequency broad band impedance figure of the machine. The real part of the machine impedance depends on the actual frequency positions of the cavity HOM's, this explains the discrepancy in the results obtained by two different methods, the synchrotron RF phase shift of the bunch and the fit of its shape.

Dipole mode instabilities of a single bunch were observed in the Accumulator. A careful reassessment of cavity modes with a 3D code demonstrated that the instability can be completely explained by the cavity HOM's. The instability can be easily avoided by either operating the cavity at a suitable temperature, or by setting the cavity tune to its full current value. One can also insert a damping device in between the circulator and the cavity. The presence of the circulator, at a short distance from the cavity, turned out to be very beneficial, not only to shield the amplifier from load variation, but also to damp a large number of cavity HOM's.

The Committee would like to congratulate the group studying impedance and instabilities (in particular Mikhail Zobov) for their excellent work over the last few years that has paid off so well in ensuring that the ring impedance would be so low.

Control System

The Committee was impressed by the progress in the Control System. The successful commissioning of the transport lines and the Accumulator have demonstrated that the Control System is capable of providing, not only remote control of individual elements, but also complete packages.

Clearly, the Accumulator Ring is small compared to the Main Rings and the problems of the Control System do not scale linearly with the number of elements being controlled. Nevertheless, the Controls Group has shown itself capable of providing the necessary capability in a timely fashion.

The plans for installing the rest of the Controls network were clear and reasonable and the Committee found no reason to believe that the Control System would not be ready on time for Main Ring Commissioning.

Interaction Region Design Update

The Interaction Region components for KLOE have made substantial progress in the past six months. The mechanical design has progressed to such an extent that construction of many prototypes are in progress to evaluate the design principles.

A change from the original design for the low beta quadrupole support was presented. It used to be supported from the rings located at the tracker inner entrance and exit ends. The KLOE group suggested supporting this triplet and inner calorimeter on a column separated from the tracker ends. A counter balance spring system has been added to minimize the moment exerted on the low beta quadrupole assemblies. This is a safety provision to assure the structural integrity of the total system.

The KLOE group requested evaluating the possibility of supporting the inner calorimeter on the low-beta quadrupole support tube. The increase of weight would require an increase in the size of the non-magnetic cam bearings which are not easily obtainable commercially. A new weight balancing device has been presented. It is a compound spring system in both vertical and horizontal direction. The system has a very low resonant frequency to avoid the effect of external excursion due to rotary machinery nearby. The idea seemed good and it is suggested that a full size prototype be built and tested prior to incorporated into the system design. However, the Committee was not convinced that the additional complication to what is already an extremely complicated problem was worth the improvement in Physics potential. The KLOE group is encouraged to go back and see whether the slight improvement (a few millimetres) in the thickness of the inner calorimeter is worth separating the inner calorimeter from the tracking chamber and the subsequent loss in fiducialisation, not to mention adding complexity in a region that is difficult to access and maintain.

A half Beryllium RF shield prototype has been fabricated by the vendor. The quality appears very good except some small spots transparent to the light, this imperfection will not interfere with the functionality of this shield. The 50 micrometer thick RF shield was considered the most difficult part of the Interaction Region vacuum chamber, it is indeed gratifying to learn that it can really be built.

The support system for FINUDA is still in a state of flux. A mechanical adjustment system is being investigated to provide substantial adjustment capability to remedy the uncertainty of detector magnetic axis and its alignment with respect to the storage ring axis. It appears to be a difficult requirement to fulfill with present cam system. Committee members are very much concerned about the potential hazards of such a system, particularly with the large angles that result in longitudinal motion at the cams and can cause interference with the vacuum chamber and the experimental equipment. It would be better to correct the bulk of the misalignment by imposing that the detector be positioned to within ±1 mm, resulting in a reduced burden on the mechanical adjustment system. The agreement between Finuda and the Machine Group already specifies this tolerance but other tolerances are involved. The Committee recommends that a tolerance budget be established for all of the components of the accelerator and detector in this region to ensure that there are no possible interferences. If, as a result of these tolerances, any of the cam motions must be limited to less than the maximum, additional hardware safety measures must be built into the system to prevent damage caused by over travel.

An optimization scheme has been investigated to facilitate the adjustment of the cams. It is the opinion of this Committee that the adjustment action should be extremely cautious and deliberate, moving one cam at a time, and should not rely on accurate synchronisation of simultaneous movements of the cams. The optimization of the cam movements should be to reduce overshoot during travel and should also incorporate a way of approaching the final set points that minimises mechanical hysteresis.

Status of the Experiments relative to the Machine

The Committee reiterates its recommendation, made at the previous meeting, that the Machine Group should assign one person to be the interface with each of the three experiments. The purpose is to facilitate communications, to prepare and make decisions and fix all day-to-day problems without unduly involving the upper hierarchical echelons.

DEAR

The interface preparations (vacuum chamber, platform) have made very good progress. The experimental apparatus appears to be ready in time for early installation in one or the other of the interaction regions, as soon as the DAΦNE Machine Commissioning progresses to the point that the centre quadrupole can be removed.

The exchange of information on background and luminosity (going both ways) between experiment and machine should now be implemented, in order to extract the maximum amount of information from this early phase.

FINUDA

The fact that the magnet has now been shown to reach the nominal field value of 1.1 T has allowed the Machine Group to place the order for the permanent magnet quadrupoles.

The mapping of the field in the detector region has been made, and the data are being processed. Additional measurements of the field along the beam have been requested by the machine group.

The resistive losses (7 W) due to the defects of the coil conductor seem to be within the planned capabilities of the refrigerator.

Work on the detector components has continued well. The "clepsydra" distortions (due to some transport mis-handling in 1996) have been corrected. Its transfer from the assembly hall to the machine pit and back was tested successfully.

It has now become urgent to plan in detail and to agree with the Machine Group the main steps that interfere with the DAΦNE machine installation (either in space, or time or both), i.e. erection of the cable support, transport and assembly of the magnet to the pit, installation of cables.

Completion of these operations, which involve industrial firms, will allow the remainder of the work (to be performed by the collaboration members) to take place during intervals of the machine commissioning phase. Clearly this will require close coordination with the Machine Group, in order not to interfere with their work.

In the present situation it seems advisable to plan the transport of the FINUDA magnet to Frascati at the earliest possible date. In case it cannot be transferred directly into the DAΦNE hall immediately when it arrives on site (expected to be the end of June), the magnet measurement hall could be used for storing it. This has the advantage of de-coupling the decision on the transport from Genova to Frascati (which requires advance notice) from that of transfer into the DAΦNE hall (determined by priorities within the laboratory).

KLOE

Compared with the situation of the last Review the following progress is noted:

- the hall and pit are ready;
- the coil (tested at half current at Oxford) has been delivered;
- the steel central yoke + one end cap are on site;
- the stringing of the wire chamber has started and is proceeding at 3 shifts/day.

Some future goals are: steel yoke (with coil inserted) closed by the end of May - Liquid helium transfer lines: installed by the end of June; cool-down in July, followed by field measurements and mapping. The magnet should be ready mid September.

The Committee is pleased to see that the above dates have not changed since the previous Review.

The whole experiment plans to be ready to be rolled into the DAΦNE Interaction Region by the end of April 1998.

Global Commissioning Strategy including Integration of the Detectors

The Project Leader presented his vision for the global commissioning strategy. Initially, each ring will be commissioned individually to ensure that all components work correctly and that the optics are as predicted. This will be done with the central quadrupole in the straight section powered. When the beam can be successfully stored, this quadrupole will be lowered in gradient. The Committee estimates that this phase may take about one month and ends when:.

- the beam can be stored in both rings with the central quadrupole switched off.

At this point, DEAR will be installed in the pit of the second experiment and two ring operation commissioned. This phase, which the Committee estimates could take up to three months, would end when:

- the single bunch peak luminosity has reached $2x10^{30}$ $cm^{-2}s^{-1}$ (which indicates that the ring optics are sufficiently well known), and
- an average of 1 pb^{-1} per day can be regularly obtained (which indicates that the reliability and operability of the machine is acceptable.

The Committee felt that the Project Leaders recommendation of 3 pb^{-1} per day for the average luminosity would be too ambitious at this stage of the Project and would recommend proceeding more rapidly with bringing the machine towards its final configuration.

When these two luminosity goals have been reached, the first major detector (KLOE or FINUDA) can be moved into position on the machine. No-one should expect that the luminosity will remain the same with the addition of the solenoidal field of the detector and the associated compensators and rotated low-beta quadrupoles. The optics of the interaction region, while designed to be optically transparent, can be expected to require some effort to ensure that they in fact operate correctly. In addition, the backgrounds in this operating condition will require some time to understand and bring under control. The Committee estimates that this phase could take about three months and should come to an end when:

- the single bunch peak luminosity has reached $2x10^{30}$ $cm^{-2}s^{-1}$ (which indicates that the ring optics have been restored),
- an average of 1 pb^{-1} per day can again be regularly obtained (which indicates that the reliability and operability of the machine with the new components has been restored,
- the backgrounds for the detector are acceptable, and
- the physics program of the two detectors has reached the initial goals established by the Scientific Committee.

At this time, DEAR would be removed, and the second major detector rolled into the ring. There will again be a period when the luminosity must be re-established in the presence of the two major detectors, the background levels restored in the first detector, and backgrounds brought to acceptable levels in the second detector. The Committee estimates that this might take about a month. It should be noted that progress with the first detector will necessarily suffer in this period and this should be understood ahead of time.

The Committee endorsed this scenario, based on the proposal of the Project Leader, and calls upon the Scientific Committee to establish at the earliest possible moment which detector is to be installed first. Once this decision is made, the work of the Machine Group and the three Detector Groups can be optimized towards common goals. In the meantime, the Committee urges the Project Leader to maintain maximum priority on machine installation.

Conclusions and Recommendations

The Committee had a series of recommendations at the end of the last Review. They are repeated here to show how much progress has been made.

- Ensure that delivery of the remaining magnets stays on schedule by all means necessary. In particular, the Committee recommends sending someone to Ansaldo at least three days a week, if not full time, until the last magnet is delivered. The mere presence of this person will maintain pressure on the manufacturer.

  The last magnet from Ansaldo was delivered during the Review.

- Assign a person to coordinate all of the system integration for DAΦNE main rings, as was done by Sannibale for the Linac and Ghigo for the Accumulator. This is in addition to the excellent job being done by Sgamma for component installation, but needs to be integrated with his schedule.

  Caterina Biscari has been doing an excellent job in this role and Francesco Sgamma has continued his excellent work of component installation.

- Assign one person from the Machine Group to be the interface with each experiment to facilitate communication. The person should be able to make decisions and fix all of the multiple small problems that are guaranteed to come up and which should not need the intervention of the Project Leader to resolve.

  This is now a really critical need.

- Put maximum pressure on the civil construction firm to complete the KLOE Hall so that it can be sealed off with the shielding wall. This will permit installation of "clean" equipment to start in DAΦNE and will also allow the KLOE group to start transport tests of their wire chamber.

  Achieved on time.

- Complete the Linac and Accumulator commissioning with the goal of producing electron and positron beams of nominal specification at the temporary wall between the Injector and the DAΦNE Hall. This should be done entirely under computer control and will test the extraction and all of the pulsed magnets that have not yet been exercised. The Committee would like to see this work completed ready for the next Review, in time to be presented at PAC in May '97.

  Virtually complete – excellent job.

- Given the likely collision between the construction of the experiments and the DAΦNE commissioning, the Project Leader should re-examine the commissioning strategy to start without the quadrupole at the interaction region. This would simplify the strategy by eliminating one step, and would also reduce the amount of modifications needed to install the simple version of DEAR. The Committee is strongly in favor of having information on backgrounds as early as possible in the commissioning.

  Presented in the course of this Review.

- The Committee would like to see a parameter list set up with the theoretical parameters and a regularly updated list of experimentally obtained numbers. This is the best way of keeping track of progress and to ensure that nothing falls through the cracks.

  The Committee would still like to see this list established – the publication of internal reports with commissioning results should make this relatively easy compared to other projects.

The next Review will take place as follows:

13th Review will be held on October 28-29, 1997

The Agenda of the 13th Review should include presentations on:

- Installation Status
- Experimental status
- Insertion Region Update
- Global Commissioning Strategy, including the Experiments
- Main Ring Commissioning Goals and Plans