DAΦNE TECHNICAL NOTE

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DAΦNE PROJECT REVIEW

Frascati, October 28-29, 1997

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Introduction

The Committee was delighted to hear that the first beam had been stored in the electron ring of DAΦNE three days before the Review. This was a major milestone for the Project and the results indicated that all of the construction and check-out tasks had been carried out with a high degree of professionalism.

The DAΦNE Hall is now open to finish installation and checkout of the positron ring, which is expected to be completed by mid-November. After this, commissioning of the two rings will begin in earnest.

While there are still a few areas of DAΦNE where construction activities continue (notably in the interaction regions), the primary focus of the machine group will no longer be construction, but rather the commissioning and preparation for becoming an operating physics tool. This is therefore an appropriate moment for the Committee to terminate, having followed the entire design and construction phase of the machine. This, the thirteenth Review, is the last of the series, which have been held regularly, twice a year, for the last six and a half years.

General

The session of the Committee was opened by the Frascati Laboratory Director, who welcomed the Members and reported on the progress made by the experiments.

Briefly, DEAR has constructed and tested all its equipment and will move into the FINUDA interaction region as soon as the central quadrupole can be removed. This is only expected to take a few days, and DEAR will then be able to take data during the luminosity commissioning phase of DAΦNE, providing valuable information on the backgrounds.

KLOE has tested and measured its superconducting coil, installed a part of the end cap calorimeters, advanced the stringing of the tracking chamber (only about 5% of the wires are still missing), and tested the Data Acquisition system.

FINUDA has mapped the magnetic field (at the manufacturers' factory), constructed and tested all the detector components, and installed some of the cables. The remaining problem is to clarify the precise alignment of the magnetic axis, for which a new set of measurements is required, and is planned for December.

Meeting the tolerances on the magnetic axis is a requirement set by the DAΦNE Project Leader. To clarify this, an *ad hoc* Committee of three experts was set up by the Laboratory Director and instructed to report their findings to him*

They recommended that a geometric survey, and then magnetic measurements inside the end cap holes be carried out. If the magnetic axis of FINUDA is shown to be within ± 0.5 mm of the geometric axis, there should be no further impediment to installing FINUDA in DAΦNE.

DAΦNE Status and Commissioning Results

The Committee is very pleased with the great progress and achievements since the last Review:

- the electron main ring installation is now complete, and the positron ring will be complete by mid November;
- the transfer lines from the accumulator to the main rings have been commissioned with electrons after a 15% field error in one bending magnet was found (it should be noted that this is the only magnet setting error so far found in the entire machine and it was a magnet measured by the manufacturer, not by LNF);
- a first electron beam, with a few mA, was finally successfully stored in DAΦNE on October 25, 1997. No correctors were needed to obtain the stored beam, an indication of the excellent alignment achieved, as well as the quality of the magnet measurements made at LNF.

The Committee expresses its warm congratulations to the whole DAΦNE staff and to the Project Leader on these achievements. This excellent start of the DAΦNE commissioning has been obtained after a very good preparation:

- all magnets have been carefully measured and the magnetic measurements are available on CD ROM;
- the vacuum level of the ring, before bake-out, is pretty good with a few 10^{-9} torr without beam. Outgassing produced by synchrotron radiation from the stored beam is already visible and currently limits the lifetime of the beam. This will improve with beam cleaning as soon as enough Amp·hours can be accumulated. If not, the capability to bake out the ring is ready, but the whole operation would take at least two months (the Committee agrees with the decision to wait until the KLOE roll-in to perform this bake-out, if it is shown to be necessary);
- the spiraling of the beam at injection without RF lasts for over 1000 turns, which corresponds to what is expected from synchrotron radiation loss per turn and is good sign of the excellent behavior of the ring;

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* See "Recommendations for Magnetic Measurements in the End cap Holes of the FINUDA Magnet", by W. Flegel, C. Lesmond, D. Newton - September 1997.

- the RF system captured the injected beam very efficiently at the first try, once the frequency was according to the measured revolution frequency;
- the first measured closed orbit of about ± 5 mm in vertical and ± 10 mm in horizontal without correction is already very good and will be improved by realignment after closed orbit analysis;
- The basic lattice optics have already been measured and are very close to the theoretical model with a transverse tune deviation of ± 0.02 and chromaticity; a great achievement for a fully novel lattice derived from the Chasman Green lattice used for synchrotron light sources, but including powerful wigglers, which was specially developed for DAΦNE.

This is an excellent start which augurs very well for the future performance of DAΦNE.

Power Supplies

The performance of the numerous power supplies of the transfer lines, accumulator and storage ring was presented to the Committee. The residual current ripple and the long term stability are within tolerances and, as a result, the observed injection stability in the storage ring was excellent.

Some small teething problems are being solved with the power supply manufacturers like bad contacts in the PCB connectors or increased ripple at some current levels. Active output filters, which were foreseen but not yet commissioned, will be put into operation on some of the power supplies to bring the residual current ripple into tolerance.

There are still 48 power supplies for the skew quadrupoles still to be delivered by INVERPOWER. These units will only be needed when the first big detector solenoid is rolled in, so the installation could occur during the shut-down when KLOE is moved into the Ring. After 14 months of delay, the first batch of 24 units is expected by mid December '97 and the second batch by mid January '98. The racks, cabinets and cabling for these power supplies will be installed beforehand. The Committee recommends that a single unit power supply be delivered earlier by INVERPOWER to check all connections as early as possible.

The combination of ground loops and parasitic contacts between the vacuum chamber and the pole of the pulsed magnets between Linac and accumulator produced arcing, together with chamber movements. The solution to this classical problem is to electrically insulate the vacuum chamber flanges of the pulsed magnets at both ends.

Fluid Systems

DAΦNE Fluid System was presented for the first time. It is a large and complex system. An evaporative cooling method, rather than a conventional chiller, was selected for reasons of better reliability and lower cost. The system is now complete and system balancing is being carried out. The piping and distribution manifolds are very well conceived, the layout in the accelerator complex is very orderly. The high quality installation job makes this complex system pleasing to observers and gives a sense of confidence in its future functioning. The system has been turned on and the performances have been satisfactory. There are a large number of flow switches installed in the system for interlocking purposes, therefore the reliability of such devices must be assured in order to avoid down time. The Committee would also recommend installing devices to provide early warning of massive water leaks.

Control System

The Control System hardware has almost doubled since the last Review and about 75% of the number of Devils are now installed. Most of the cabling and low level drivers are also installed, and a large fraction of the rest will be completed in the next two weeks in time for commissioning of the positron ring. The Control room is now functional with five consoles and an additional workstation. This part of the controls task – providing remote control of every element – requires a lot of detailed work: installing cables, replicating software, and checking out all of the connections. Indeed, over the last few months, this has required transferring a considerable number of people within the group to concentrate on completing the basic system (from one to a peak of seven), still a small number compared to other laboratories. The Group is to be congratulated on successfully completing this task in time to support the commissioning.

There is also a series of higher level software that was successfully tested during the commissioning. The timing system worked perfectly – a real success story given the complexity of the system. Beam orbits could be obtained, although not with the final system. The vacuum could be measured and logged and the tunes measured. To have all of these programs operational for the first days of commissioning is a credit to the controls and diagnostics groups.

By necessity, there were few new high level applications. However, the Committee was pleased to see a few applications created by people outside the controls group. In particular, an optics program written in LabVIEW by Miro Preger is a good example of the future capabilities of the control system.

The Committee supported the upgrade of LabVIEW from Version 3.1.1 to Version 4.0.1, even though software upgrades are always painful. It will be necessary in the future to provide upgrades to the commercial software underlying the control system as well as to the software written in house. This is a challenge to manage successfully, never allowing the software to be so old as to not supported, but never jumping on the latest version before all of the bugs have been corrected. The cost of the software and hardware maintenance, licenses and upgrades is regrettably high given the rapid development of the technology and these costs must be included in the annual budget.

The Committee had only a few recommendations, given the obvious success of the control system.

- We would recommend looking very carefully into providing UPS (Uninterruptable Power Supplies) for all the computers (including the DEVILs) as the cost of lost operations due to a computer crash is very high and usually outweighs the cost of providing the back-up power. The units chosen should also include transient spike protection.
- We also recommend providing a software development environment which allows an example of every program to run simultaneously. This will pay for itself the first time that a major software upgrade is required by ensuring that all of the operational software is compatible.
- During the first days of commissioning, a member of the Controls Group is always present in the control room. This is clearly not the best long term solution and it will be necessary to develop procedures to permit debugging problems by a software on-call person, preferably from home to provide faster response.

In conclusion, the DAΦNE Control System was a source of great worry to the Committee at the beginning of the Project. The Controls Group has clearly demonstrated the validity of the original concept, their ability to bring on line this new system, and to provide all of the required capabilities in an extremely cost-effective manner.

Interaction Regions

The mechanical designs of interaction region for both KLOE and FINUDA are converging. The prototypes of Low Beta Quadrupole adjustment cam systems have been made and testing will take place in the near future. The tooling for the insertion of the completed mechanical assembly has been designed, and appears to be well conceived.

Undue stress on the Beryllium chambers caused by transferring the assembly from the insertion tooling to the support structure should be avoided. The cam systems for both ends of the interaction region should be controlled by a common PLC, programmed with the appropriate safety measures to ensure that no damage to the vacuum chamber is possible under any circumstances. It is suggested that a dummy interaction region chamber be used for practice and test prior to using the real Beryllium chamber, to avoid inadvertent damage to this expensive and very long lead item.

The spherical Beryllium chamber for KLOE interaction region is progressing satisfactorily. The two hemispheres have been machined and etched to the proper thickness. The welding operation of these two parts has been delayed for about seven weeks due to the interruption of electrical power at the vendor's plant in Russia. The end tubes, also made of Beryllium, are partially machined. The final machining will be done to match the dimensions of the welded sphere. The prototypes of the improved RF shield have been on hand for some time. The real parts will be made after the dimensions of the end tubes have been decided. The KLOE Beryllium chamber is an extremely difficult component and has gone through a very long development period. When it is fabricated, it will be the first such chamber joined by a TIG welding process rather than "Fluxed Aluminum Alloy" brazing. The brazed joint with flux requires a thorough cleaning procedure to avoid corrosion problems, and this is not possible in this design. The Project Leader will need to follow developments closely and decide if it will be necessary to initiate construction of a back-up chamber of a more simple design (straight tube). Despite the less than optimum performance that this would provide, roll-in of KLOE cannot be delayed because of the lack of an interaction region vacuum chamber.

Cryogenic Plant

The DAΦNE Cryogenic System was also presented for the first time to this Committee. It is a large and complex system which serves two detectors and four compensators. The plant, decided and built under a very tight schedule, has proved to be very successful. One should remark that the specification was sent out to industry in June, 1995, that the contract with the manufacturer (Linde) started only 21 months ago and yet, within one year, the plant was being installed at Frascati. The plant has passed the acceptance tests in July of this year.

The plant capacity has surpassed the conservatively estimated requirement of all intended users. It has been continuously operated for three months, without any problems, for the KLOE magnet coil acceptance tests and the magnetic field mapping tasks. The responsible engineer M. Modena is to be congratulated for a job well done in such a short time.

Future Plans

The plans for commissioning the accelerator and beginning the experimental program are now becoming much firmer. At the last meeting, the Project Leader proposed a scenario which was endorsed by the Machine Advisory Committee. This plan was presented by the Laboratory Director at the LNF Scientific Committee June 9-10, 1997 where it was approved in principle, with the caveat that the exact dates may change. Given the present state of the machine studies and the preparation of the experiments, a delay of roughly three months from the schedule presented at that time would now seem reasonable. This would allow the luminosity in DAΦNE to be properly commissioned, give the KLOE group time to perform complete system checks, allow the FINUDA group the time to complete the measurements of the magnetic axis of the solenoid, and finally give the DEAR group a better chance at obtaining a reasonable integrated luminosity.

The Committee continues to put the highest priority on obtaining high integrated luminosity in DAΦNE. This means developing simultaneously high single bunch current, high single bunch luminosity, high number of bunches and a reasonable availability. This will undoubtedly take several months of heavy commissioning and beam cleaning of the vacuum pipe (needed for good beam lifetime and low backgrounds). Rolling in the large detectors during this initial commissioning period is counterproductive.

The approximate timetable is estimated to be as follows:

First beam stored in electron ring	October 25, 1997
First beam stored in positron ring	End November, 1997
First collisions	December, 1997
Install DEAR in FINUDA interaction region	January, 1998
Commissioning of high average luminosity	January – May 1998
Move KLOE into ring and install FINUDA in pit *	June – August, 1998
Recommission DAΦNE with KLOE and DEAR	September – December 1998
Remove DEAR and move FINUDA into Ring *	January, 1999
Recommission DAΦNE with KLOE and FINUDA	February, 1999
Full operation of DAΦNE with KLOE and FINUDA	April, 1999

* Contingent on DAΦNE achieving a single bunch luminosity of 2×10^{30} $cm^{-2}s^{-1}$ with acceptable backgrounds, and delivering 1 pb^{-1} per day in routine operation.

Conclusion

DAΦNE will have 6–12 months advance on the B Factories at SLAC and KEK in producing high intensity collisions. During this time, the laboratory has the opportunity to establish itself as the leader in understanding the new generation of high luminosity electron factories. This is the opportunity to ensure that the individual scientists and the laboratory in general obtain the recognition for the excellent work that has been done up to now. The Committee is confident that the DAΦNE Team will rise to this challenge as they have risen to the construction challenge. The Committee is looking forward to seeing Frascati establishing a strong position in accelerator and high energy physics.

On a personal note, the Committee would like to thank the Project Leader and all the DAΦNE Team for their dedication to making clear and open presentations during the last six and a half years and for the warm welcome that we have always enjoyed. We all end this Committee with feelings of regret that we will no longer be such regular visitors to the Laboratory, but confident in the knowledge that our job is complete, and that the DAΦNE Team will be able to bring the Project to a successful conclusion.