Report of the 4th Meeting of the ILC Machine Advisory Committee

Fermilab, April 26-27, 2007

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Apologies: Norbert Holtkamp, ITER; In-Soo Ko, PAL; Philippe Lebrun, CERN; Burt Richter, SLAC

Introduction

The 4th meeting of the Machine Advisory Committee (MAC) for the design of the International Linear Collider (ILC) was held and hosted by Fermilab on April 26-27, 2007. The committee was charged to review the plan for research and development (R&D) which will be necessary before the start of ILC construction.

The committee was asked to assess whether the resulting Reference Design is appropriate and complete and whether the effort is well coordinated across the three regions. The committee's mandate is appended to this report.

The meeting consisted of one and a half days of plenary presentations by team members of the Global Design Effort (GDE) followed by discussions among committee members. The meeting agenda is appended to this report.

The committee would like to express its thanks to Fermilab for the preparation of the meeting and for its hospitality.

The committee would like to thank the attending members of the GDE for their efforts to provide comprehensive information on the R&D program.

Comments on R&D Strategy and Overview

Bill Willis described the effort of the R&D Board (RDB) of the GDE in defining and coordinating the worldwide R&D programme. The committee endorses the approach of collecting R&D items as proposed by the collaborators, categorizing them, prioritizing them, and seeking contact with funding agencies to provide guidelines for funding. This appears to be the right way to start coordination of the R&D effort. The committee acknowledges that this approach is working and success is now starting to show. In particular, the areas where R&D is needed have been successfully identified. The committee also acknowledges that links between R&D coordination and funding agencies are being established. There are signs that collaborations are becoming more effective in sharing the work and avoiding duplication.

The committee however notes that the process of involving the funding agencies worldwide in supporting a well-balanced worldwide R&D program is still incomplete. The committee encourages ICFA & ILCSC to use their influence to help mitigate the difficult situation in parts of the worldwide collaboration.

The committee would like to note that the result of the effort in defining and prioritizing a worldwide R&D programme would be more convincing if the process could be made more transparent. Difficult decisions could then be discussed better among those working on the ILC, and the case for funding could be made more convincingly with the funding agencies. The committee suggests that this could be accomplished by spelling out how criteria like cost savings, relative cost savings, risk mitigation, availability, increase of performance margin, operational efficiency, operation cost savings, coupling to other R&D projects, regional balance and R&D opportunity are weighted to come to a decision on priority. In this context an inventory of required and available resources would be helpful.

Americas Regional Team R&D Program

The committee acknowledges that a tightly coordinated R&D programme is being carried out in the Americas.

The committee is pleased that the Americas' ILC budget is continuously increasing and that the future budgets have a certain degree of predictability, which is a good base for organizing the R&D effort. The level of funding amounts to 42 M$ for the dedicated ILC effort in the present fiscal year, which demonstrates the strong support of the ILC by the funding agencies in the Americas. This support has been taken advantage of by defining a balanced, focused and well organized R&D programme.

The committee acknowledges the coordination of R&D with other regions. Efforts have been reduced on BDS and Positron Source in the Americas because of efforts which have taken place in other regions. However the committee notes that every aspect of the ILC design is represented in the Americas R&D programme. The committee interprets this as a sign that international coordination and work sharing is still in its early stages. The committee is looking forward to the R&D effort being more strongly focused in the future.

R&D Program carried out in Europe

The committee welcomes recent Russian contributions to the world wide ILC efforts and expects that the R&D activities will greatly benefit from the expertise which resides in the laboratories of the Russian Federation.

The committee acknowledges a reasonable level of funding in Europe from different sources, but is concerned about the flat or even decreasing funding profile.

The committee encourages the European ILC collaborators in their efforts to obtain FP7 funding for ILC activities. The committee hopes that the European Commission will continue supporting the scientific and technical research activities which are necessary for progress of the ILC-related R&D efforts.

The committee hopes strongly that CERN involvement in ILC will continue at least in the form of making use of the synergy between ILC related R&D activities and the design and R&D work for other plans and projects, as well as by making CERN expertise available for ILC related R&D.

R&D Carried out in Asia

The overall effort in Asia is considered to be at a reasonable level.

The committee is pleased that a rich program is developing in Asia, with growing contributions from Korea, China, and India.

The committee, however, would like to encourage at this point stronger coordination of Asian activities to prevent the development of duplication and gaps in the R&D program. Because of the increasing activities, coordination in Asia represents a challenge for the Asian Regional Director of ILC, who is doing excellent work. Nevertheless, the committee would like to suggest that the GDE Asian Director should enhance these activities by devoting full time to coordination in Asia.

The committee is pleased by the activities at the KEK Accelerator Test Facility (ATF), a test storage ring for studying accelerator physics issues related to the damping rings; ATF is now being enhanced to ATF2 which includes a beam delivery test section. ATF is a truly international project which has large contributions from outside Japan.

The committee would like to emphasize that Japanese contributions to the development of superconducting cavities are vital for the success of the ILC R&D programme.

The committee did not understand the prioritization of the STF1, STF2 programs; the technical, schedule and budget goals for each step should be clarified.

R&D on Damping Rings (DR)

The committee observes that there is a large and impressive effort in planning the rich damping ring R&D effort.

The committee notes that many contributions to the damping ring R&D are made informally by many individuals which can devote only a small fraction of their time to ILC. The committee sees a certain risk that these resources might go away if the priorities change within the laboratories. A considerable schedule and planning risk is also created by the relative inefficiency of too many small contributions.

The committee encourages GDE to prepare a formal framework for the R&D work to be carried out; this would be especially helpful for the Damping Rings.

The committee strongly supports the plans to carry out electron-cloud related studies, both theoretical and experimental, with conditions as close as possible to those of the ILC damping rings. The committee agrees with the damping ring area managers that R&D efforts on electron-cloud issues must be emphasized and particularly well supported since the understanding and successful mitigation of the electron-cloud effects in the positron damping ring is of paramount importance for the present ILC reference design with just one positron damping ring.

The committee supports a strong and clear request for a demonstration of the mitigation of DR performance risks. A formal request issued by the GDE to the laboratories would probably be very helpful, and would help to make decisions on prioritization within the laboratories for providing the necessary sources of funding for such activities.

S0/S1 Programs

The committee acknowledges a broad world wide effort in conjunction with the S0 and S1 taskforces which have the goal to provide an 80% yield of cavities which provide a gradient of 35MV/m and a 95% yield after another processing cycle on cavities which failed the acceptance test. The so-called tight loop approach which is an attempt to control all relevant parameters of the cavity conditioning and to

verify testing the reproducibility by cycling the same cavities in all three regions using the same procedures everywhere has been started. The assessments of results seem sufficiently well coordinated. However, the recent most successful recipes are not followed yet in all laboratories.

In view of the large expense and the large effort and the large need for resources, the committee suggests that the methods and procedures in the tight loop approach be continuously monitored and optimized and the adoption of the optimized procedures be better coordinated.

Single cell gradient improvement (different shapes, large grain and single crystal materials) achieved by JLAB/Cornell/KEK with different treatment processes look very promising: gradients above 40MV/m have been achieved reproducibly with a number of cavities. This is a very encouraging result, which might well lead to a proof-of-principle demonstration once it has been extended to dressed multi-cell cavities.

The results of these studies of single cavities should be fed back effectively to the nine-cell cavity fabrication recipe.

Electron beam welding (EBW) is one of the critical issues in cavity fabrication procedures, in order to make QA, cost reduction, and industrialization. Systematic studies should be organized to find the optimum EBW parameters and conditions, to develop the specific mechanism for mass production.

The committee is looking forward to the submission of a generally accepted recipe which includes a comprehensive description of the procedures, the parameters, the materials, the required monitoring, the definition of equipment to be used, the necessary equipment maintenance procedures and the quality requirements and controls of the materials.

The committee recommends regular assessment of the work performed and the status of achieving the R&D goals.

S2 Program

The S2 programme is aimed at demonstrating the performance of the ILC acceleration system by performing a series of string tests. The plans range from the test of an RF unit which includes the modulator, the klystron, the RF distribution systems and three cryogenic modules.

Although the necessary RF processing time for the RF main coupler has been much improved, the committee encourages further improvements not only in processing time, but also in fabrication and assembling cost reduction.

The committee strongly supports the ILC S2 program goal to conduct a full-scale RF unit string test.

The committee, however, feels that the necessity for testing the exact ILC system is overemphasized. The GDE RDB should take into account in prioritizing the S2 programme that the final ILC acceleration system will most likely be different from the prototype systems. The request to perform string tests on the final system prior to project approval appears to be difficult to reach with the present route map for the ILC. However, before series production of modules starts, a string test with fully equipped modules in their final configuration with beam is necessary. The issues of Higher Order Modes in various components, cavity tuning control and cryogenic testing are examples of high priority topics for these tests.

While the committee recognizes that the efforts to provide a solid base for the industrialization of the superconducting RF technology in each region is of paramount importance for the realization of the ILC, it would like to emphasize the importance of fully exploiting the synergy with existing programmes (SNS, XFEL, CEBAF 12GEV upgrade, smaller superconducting linac projects such as FLASH). The GDE should take an aggressive attitude in making requests to the partner laboratories to support this strategy.

A consequence of the exploitation of synergy is that the S2 R&D efforts could be more tightly coupled to, and coordinated with, the ongoing or planned projects. Despite the technical differences in the details of the cryostats, the existing superconducting RF projects could provide much of the necessary information on logistics, assembly, testing and commissioning procedures, and system integration for the ILC, and are expected to provide valuable input for desirable technical design changes.

Close connection with the above programs might avoid unnecessary effort which stretches far into the future and possibly impacts the ILC project schedule.

In particular, the ILC R&D activity should keep up its efforts to exploit the possibility of carrying out ILC specific studies in existing superconducting linacs. As an example, one should aim for testing an ILC prototype cryostat in FLASH or XFEL.

RF Systems

The committee wants to express its appreciation that the R&D programme of the ILC RF systems is making steady progress. The committee has no significant concerns regarding the feasibility of the RF system.

The ILC reference design is based on existing but expensive modulator technology. The committee is pleased to see some progress on an alternative modulator design based on the modular Marx generator concept which promises a considerable cost reduction and improved maintainability. The committee is looking forward to first full power tests of the prototype modulators which are expected to be performed soon.

The committee is pleased to learn that the Toshiba klystron which performs according to ILC specifications has by now approximately 800 hours of operating with no signs of degradation. The committee looks forward to further long term tests at full power.

The committee is still concerned about the fact that for the time being no further vendor is able to deliver ILC-like klystrons. The committee recommends strengthening the ILC programme in support of a broader base for this key component.

R&D efforts on a high efficiency sheet beam klystron with ILC parameters should be supported if resources are available.

The committee is pleased about the RF distribution plans. The present scheme with hybrids and voltage tap-offs appears to be an improvement over the previous designs. The committee takes note that there is more than one solution for a flexible RF distribution. This is considered very important because of its large impact on the acceptance criteria for superconducting cavities which is very cost relevant. The committee is looking forward to successful high power testing of the first tap-off prototypes.

Beam Delivery System

The committee acknowledges that considerable progress has been achieved with the Beam Delivery System (BDS). All the important critical systems of the present single IR scheme with 14mr crossing angle are represented in the R&D program. The R&D plan has been worked out in great detail and the goals of the R&D are well aligned with the global ILC roadmap.

The committee takes note of difficulties in achieving sufficient stability of the IR quadrupole magnets. The committee encourages allocating sufficient priority and resources to resolve this very demanding technical problem. The committee endorses and encourages experimental tests at ATF2.

The committee notes that the detector push-pull scenario is being worked on. The committee would have liked to see more details of this. As an example, the push-pull scenario might have a strong impact on final focus alignment and stability issues. The committee wants to make sure that this issue is given sufficient attention.

The committee encourages further strong interaction between accelerator and detector designers on machine-detector interface issues.

The committee is pleased to see that the crab cavity phase stability requirement can be achieved. The committee would like to see a long term test of this type of high stability operation.

The committee feels that alternative BDS designs (two IRs, different crossing angles) should either be fully investigated and worked out, or should be given only minimum attention.

The BDS team should pay attention to crab cavity effects caused by spurious vertical dispersion in the main linac, residual coupling at the crab cavity, and similar accumulation of small effects.

R&D on Particle Sources

The committee notes that a summary was provided of many activities, and attention should be paid to their effects. The committee acknowledges progress with positron sources.

The committee is concerned about (or may need to understand better) the margin in the positron yield.

The committee encourages assessing the synchrotron radiation load and collimation on the undulator beam pipe.

Meeting Agenda

The agenda of the meeting and copies of the presented slides can be found on the internet at the following address:

http://ilcagenda.cern.ch/conferenceDisplay.py?confId=1388

Appendix: Mandate of the MAC and meeting Agenda

22 March 06

ILC Machine Advisory Committee (MAC) Mandate

1. The oversight of Global Design Effort (GDE) activities is by the International Linear Collider Steering Committee (ILCSC); MAC will assist ILCSC in one of ILCSC's oversight functions.
2. MAC will meet two or three times per year until ILCSC and the International Committee for Future Accelerators (ICFA) approve the Reference Design Report (RDR).
3. MAC will review GDE accelerator activities; it will report to ILCSC.
4. MAC will review the following aspects of the Baseline Configuration Document (BCD):

a) Is the conclusion of BCD reasonable and consistent with the overall ILC system? Is the BCD design consistent? Is it optimized to produce maximum physics output? Is the plan to upgrade the machine to 1 TeV appropriate?
b) Are there any BCD items that MAC feels should be reconsidered?
c) Are there any issues that MAC thinks should be discussed in a broader context by ILCSC?

5. MAC will review the process that will lead to the RDR:

a) Is the organization of GDE appropriate for this activity?
b) Is the accelerator design process appropriate?
c) Is the cost estimate process appropriate?
d) Are the milestones envisioned in the RDR appropriate and realistic?

6. In addition, MAC will review the RDR for the following:

a) Is the RDR design reasonable and consistent with the overall ILC system? Is the RDR design consistent? Is it optimized to produce maximum physics output? Is the plan to upgrade the machine to 1 TeV appropriate?
b) Is the estimated cost reasonable?
c) Is the envisioned project schedule reasonable?