Report
of
the JLC Globalization Committee

December 16, 2002

JLC Globalization Committee

Executive Summary

There is now a worldwide consensus among the high energy physics communities that the next facility to be constructed should be an electron-positron linear collider, which should be operated concurrently with LHC. Three regions in the world, Asia, Europe and North America, are conducting serious R&D and design work for a linear collider. Although the technological approaches vary, it is widely conceived that such a high energy linear collider should be built and operated through global-scale international cooperation. In view of the long history of international collaboration in this field and the common prospect for the future, it is a natural way to proceed. Detailed studies were made by a committee established at KEK regarding what might be the best organizational structure for building a linear collider in Japan, how it can be created, and how it should be operated. The laboratory is referred to as the Global Linear Collider Center (GLCC).

This committee, after having investigated various examples of large international facilities, studied different possible models for the linear collider laboratory. It also considered in depth what are the necessary features for the organization which builds and operates the collider, and facilitates large international collaborations for experiments taking into account the anticipated budget and time span for the linear collider. Preliminary estimates of the total cost for the construction are in the range of 3–4 billion US dollars; the lifetime will be over 20 years, with an upgrade at a certain stage. Among many requirements at different levels, firm commitment of the participating partners and their stable support throughout the project are critical, while flexibility for the scientific program is important and a timely start is desired. Another indispensable feature is the attractiveness of the entire project to the general public, to the young generation of particle physicists which potentially become users, to wide areas of the science community, and to politicians and governments. Regarding the organization, openness to anybody who is interested is important, because of the nature of the science to be pursued. The management of the organization must be clear and transparent.

Two possibilities for a cooperation scheme have been worked out in view of the above requirements. One is an extension of an existing laboratory in which the host country takes over a major fraction ($\gtrsim 75$ %) of the construction and operation cost and receives the remaining contributions from abroad (like the HERA model). The other is the creation of a new globally international laboratory in Japan, in which the cost would be more evenly distributed among the partners while the host is expected to contribute the largest sum. Since these are extreme cases at opposite ends, an intermediate model was also considered. That is, some type of joint venture of interested institutes from many countries, with the purpose to construct and operate a linear collider. This model may lack somewhat in long-term stability and, therefore, is not favored, although it can be useful in initiating a large-scale international collaboration to prepare for the desired establishment.

It was considered to be extremely challenging for Japan, or any other single country in the world, to finance such a large fraction of the cost that would be needed for the extension model. It would also be unlikely for this model to provide sufficient human resources with the necessary expertise without a substantial international cooperation.

For several reasons, creating an international laboratory that is open to all high energy physics communities world wide is the preferred solution. In principle, all partners should be on equal footing. A laboratory based on an international treaty is the best suited for securing financial support and stability over the duration of the project. It is deemed that the time needed to arrange a treaty-based agreement would not be long compared to what is needed for the parties to reach a consensus over the details of the project. The latter is required for any international cooperation involving a substantial financial commitment by the governments over a period of decades.

Such a global laboratory, unprecedented in the field of particle physics, could serve as an outstanding center of excellence in Asia, and would have a considerable impact on the whole world. For Japan, to host such a laboratory would be very attractive and it would be in accordance with its national plans for science and technology.

The organization will be lead by a director (or directorate), who will be selected by a council, and report to it. Members of the council will be government officials of the participating nations and scientists thereof appointed by their governments, as well as representatives of the users.

The key personnel of GLCC will be employed by the laboratory and will be selected based on expertise. It is expected that a large number of scientists would either be seconded or visiting to the laboratory from the participating institutions. A reasonably frequent exchange of people is regarded as being necessary in order to keep all of the participating laboratories constantly active in the linear collider project, for instance, by carrying the responsibility of R&D programs for an upgrade.

As an action towards the desired solution, this committee recommends the creation of a "Pre-GLCC" (Pre-GLC Collaboration or Pre-GLC Center), in order to conduct the necessary R&D for the accelerator and to study the details of the organization. Pre-GLCC would have a structure similar to GLCC, but based on a MoU of interested laboratories, rather than government-level treaties. Pre-GLCC is not only the coordination body for the world linear collider machine, GLC, but is also a world-wide team chosen by the collaboration which consists of all laboratories and institutes working for linear collider projects. Several forms of international collaborations on accelerator R&D have been quite active within the framework of TESLA, JLC/NLC and CLIC. An important responsibility of Pre-GLCC is to push the world efforts one more step ahead, based on the achievements obtained by these teams. This has to be done at both the technological and organizational fronts, with a clear intention for the joint construction of a linear collider. Obviously, close communication links, open sharing of technical information, and the cultivation of a common, collaborative spirit among various layers within the participating laboratories, would be of critical importance, which would require conscious efforts by all parties involved. The International Linear Collider Steering Group (ILCSG) having been formed under ICFA, may take an initiative to create Pre-GLCC. In due time, government officials will have to be consulted concerning this activity. In fact, government officials have been involved in the discussions on a long-term road-map of particle physics within the framework of the Global Science Forum of OECD. In future, however, a larger platform should be created for everybody who is interested in participating.

There are many issues left for further consideration regarding the organization, such as how to evaluate different types of contributions, proper rules for later accession and withdrawal and so on. The most important issues are listed in this report.

One important point is the role of the host. The project will bring many benefits, but also a large responsibility for Japan as the host country. It is a major challenge for Japan to provide the necessary infrastructure, for the smooth construction and operation of the linear collider, for example, to prepare accommodations and appropriate living conditions for a large number of collaborators with their families. Solutions have to be found concerning international schools, medical care, visas, work permits for accompanying persons, tax and import/export questions. Until its birth, or even at an early stage of the new organization, KEK may need to take a substantial role in handling these problems, although it will eventually be one of the participating laboratories. For this reason, KEK may have to go through a major change in its structure.

In conclusion, this committee considers the creation of a new treaty-based international laboratory as being the best way to ensure its long-term stability and clear legal status, leading to the construction and operation of the linear collider. An intermediate step should be taken by starting a Pre-GLCC in which interested laboratories and institutes can join and work together to solve the technical and scientific issues in order to be ready for the construction. In parallel, it can also prepare for GLCC by cooperating with government officials to work out the treaty for establishing this International Laboratory.

Contents

1 Introduction

The linear collider (LC) is an ideal facility to solve the contemporary problems in particle physics. Two decades ago, the high energy physics community in Japan decided for future planning to give the highest priority to an electron-positron LC at the TeV-energy range [1] (JLC project [2]). The plan, which requires a highly sophisticated accelerator technology, was backed by the experience of the TRISTAN collider in KEK, which once recorded the highest energy of electron positron colliders before SLC and LEP, and of the KEKB collider, which keeps overwriting its own world records in luminosity. On the experimental side, many physicists have worked at these colliders and/or other energy frontier machines in the world. Thus, the idea of building a LC in Japan emerged as a natural consequence of the community's steady and healthy development. Since then, many efforts toward the linear collider have been put on investigating its potential for particle physics, and to advance accelerator R&D. There has been increasing support for a LC project among the Asian high energy physics community. The Asian Committee for Future Accelerator, ACFA [3], has recommended the construction of such an electron-positron LC in the Asian-Pacific region as a 'globalized' project, and urged KEK to take the initiative.

There have been also similar activities for electron-positron linear colliders in Europe and in North America. By now, each region, Asia, Europe and North America, has reviewed its future projects in high energy physics, and has come to the same conclusion, namely that a LC is the next most desirable facility to pursue in the energy frontier of physics, and that it should be built and operated concurrently with LHC, as described in Sec. 4.2. Further, it is generally accepted that a LC will require international cooperation on a global scale for its construction and operation. The scale of the project is briefly summarized in Sec.3.

Several groups have already been working on preparing a case to host such a world machine – Europe, North America and Japan. This report presents the Japanese case. The linear-collider laboratory, if it is built in Japan, could serve as a center of excellence in Asia and have a considerable impact on the whole world. It would be very attractive for Japan to host such a laboratory. This would be the first large-scale international project hosted by Japan in basic science. The laboratory would become a monument not only to announce Japan's contribution to the world in basic science and leading-edge technology, but also to show Japanese leadership in its efforts for the world-wide integration of science and technology.

In April, 2001, the JLC project was given a fresh boost when a new promotion committee (JLC Promotion Committee) chaired by the KEK director H. Sugawara was formed.

In parallel to the JLC Promotion Committee, the present committee was organized in July, 2001, to scrutinize the *internationalization* of the JLC project and of KEK itself. The member list and the history of the committee's activity are summarized in Appendix A and B.

Assuming a new organization, called the Global LC Center (GLCC), the mandate enquires how such a center might be organized and operated, and how the KEK laboratory itself should relate to the center. This report presents the results of the work done by this committee. Although discussions are made mainly on issues specific to JLC/KEK, there are also many considerations which are more general and relevant for any global-scale cooperative project.

In this report, the main subjects, namely the possible scheme of GLCC, and the process towards its realization as well as issues to be solved, are discussed in Secs. 6–9. To help the discussion, we briefly summarize the scale of the linear collider project in Sec. 3, the trends in high energy physics (HEP) and the consensus achieved in the world HEP community to build a LC in Sec. 4, and the necessity and benefits of globalization of the project in Sec. 5.

2 Charge to the Committee

The present committee has been requested to study organizational issues which are necessary and relevant for GLCC to be built in Japan. Particularly, how to realize GLCC is the central issue to be answered. The mandate given by the Director General of KEK to the committee is:

1. Define the basic structure of GLCC, including the management and decision making processes.

2. Define the relations of GLCC with KEK, the Japanese Government, participating institutions, governments that participating institutes belong to, HEP-related NGO's (ACFA, ECFA, ICFA and HEPAP), and users.

3. Define the relationships among national governments.

4. Define the structural change of the host institute in terms of its organization, operation and management.

5. Define a road-map to establish GLCC.

6. Define the relation between the prefectural/municipal governments and GLCC.

7. Define the roles of the local governments especially concerning the natural and social environment and living conditions.

3 The JLC Project

This section summarizes the essential features of the project to help our discussion. Several reports on the JLC project have been published and are available elsewhere [2]. The LC consists of a large-scale accelerator and a detector(s) at the collision point of the electron and positron beams. The central part of the accelerator consists of two linear accelerators, one for electron and another for positron acceleration, installed in a straight underground tunnel whose diameter is of the order of four meters and the total length is 20–30 km, which is comparable to the circumference of the LEP/LHC tunnel at CERN, the world's largest accelerator, so far. As the design energy increases, the straight linear-type collider is more efficient than the circular one, like TRISTAN and LEP, because there is hardly any synchrotron light emission along the particle trajectories.

The bunches of electrons and positrons are accelerated from opposite directions, and collide in the center of the detector with nanometer accuracy. This minute adjustment of the colliding two beams is a challenge to modern technology. After a collision they may annihilate before producing new particles, while retaining the entire energy of the electron and positron beams. These collisions are similar to that which occurred during the Big Bang, the birth of our Universe. They can produce, from the vacuum, a massive particle or a bundle of particles, depending on the available energy.

The accelerator consists of millions of parts precisely machined within a sub-micrometer accuracy to accelerate and to control the beams for collisions with nanometer accuracy. The system is huge, complex and should be very precise. The project requires a number of technical innovations to produce extremely energetic, compact, high-current beams under precise and stable control. The high energy physics experiments are among the most complex equipments ever built by Humankind. The initial aim of the project is to perform experiments at an e^+e^- center-of-mass energy of up to 500 GeV, with a provision for further extensions to the TeV-scale energy.

After completion of the essential R&D and the approval of funding, the construction of the accelerator and the detector facility is expected to take 5–7 years. After experiments during the initial phase, which are expected to last for nearly ten years, newly discovered physics would very likely require an upgrade of the accelerator to higher energy ($\geq$1 TeV). Hence, the project will extend over more than two decades.

An evaluation of the necessary cost and human resources to construct and operate the facility is still on-going. Here, we simply quote typical numbers for illustration purposes only. The total construction cost for a LC facility is currently considered to be roughly 3–4 B$, which is comparable to the LHC project under construction at CERN. The electric power necessary to operate the accelerator is estimated to be $O(100)$ MW, and hence the operational cost will exceed 100 M$/year. At least 300 accelerator scientists and an additional several hundred engineering and technical staff, totalling ~1000 experienced scientists and engineers will have to work for the construction[1].

A similar amount of human resources may be required during the upgrade phase of the LC. Figure 1 shows a possible profile of the necessary cost and human resources as a function of time. A larger number of scientists, probably of the order of 2000 physicists or more, are expected to join the experiments as users of the facility. Hence, throughout the project, during the construction, operation, and upgrade, thousands of scientists and engineers with expertise, will have to work together for the project.

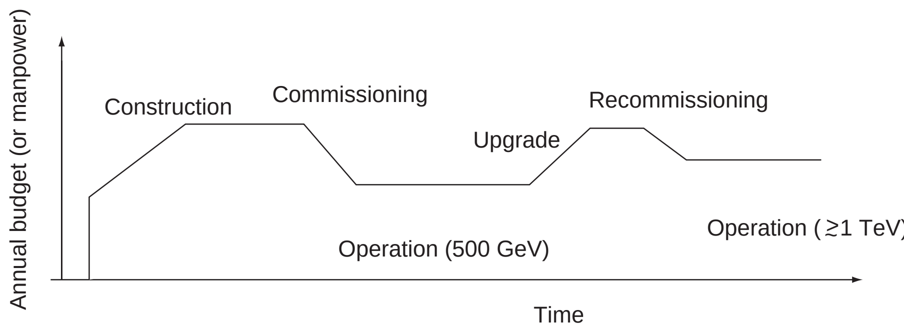

Figure 1: Possible variation of the required funding and/or human-power during the life of GLCC.

4 Trends in High Energy Physics and World Views on the LC Project

4.1 Trends in High Energy Physics

By the mid 70s, much knowledge had been accumulated, upon which the so-called Standard Model of elementary particles was constructed. It assumes that the most fundamental particles are quarks, leptons and four types of gauge particles which generate forces.

During the past three decades the central issue of high energy physics was to establish the validity of the Standard Model, or to find a breakthrough in order to go beyond it for a deeper understanding of Nature. For this purpose, new particles whose existence were predicted by the Model were searched, and, once discovered, their properties were studied to test if they meet the predictions. Several heavy particles were found, and

[1]Currently KEK has about 120 scientists in the Accelerator laboratory, and more technical staff and staff from companies dedicate to construct and maintain the accelerators.

their properties were examined. In particular, four particles, two of the heavy gauge particles ($W^\pm$ and Z^0), the top-quark, and the so-called Higgs particle, which gives masses to all particles, were searched for for a long time. By now, all of them, except for the Higgs particle, have been found. The discovery of the heavy gauge particles, $W^\pm$ and Z^0, achieved by the colliding proton-antiproton beams at CERN, gave sufficient confidence that the Standard Model should basically describe Nature correctly.

Concurrently, a number of experiments have been performed with e^+e^- colliders (TRISTAN, SLC, and LEP) operated in different laboratories around the world. Precise measurements revealed the details of particle properties and their interactions, and thus allowed us to test and establish the Standard Model. However, the story does not end here. The Higgs particle is still missing, although information on its properties has been accumulated in past experiments. Furthermore, new observations have appeared which do not fit the Standard Model, by neutrino oscillation experiments, such as Super Kamiokande and SNO. Also, CP violation in the B meson system discovered at KEK and SLAC has stimulated further efforts to scrutinize the origin of CP violation, and to look for other manifestations of new phenomena in rare B-decays. Together with some theoretical weakness inherent to the Standard Model, the experimental status urges physicists to make another step to explore the deeper structure of Nature.

4.2 World Views and Activities on the LC Project

Motivated by the above reasons, the activities for the LC project have rapidly expanded to a global scale. In Asia, ACFA [3] was established in 1996 in order to strengthen collaborations in accelerator-based science in Asia among the following twelve member countries or region: Australia, Bangladesh, China, India, Indonesia, Japan, Korea, Malaysia, Pakistan, Taiwan, Thailand and Vietnam. In 1997, ACFA issued a statement to recommend the construction of an electron-positron LC in the Asian-Pacific region as an international project. In a second statement [4] endorsed in 2001, ACFA set clear goals, as we shall see below. Similar activities were also undertaken in Europe and North America. In Germany, DESY is leading the work for a TeV Energy Super-conducting Linear Accelerator (TESLA) [5] within the framework of the TESLA Collaboration, which produced a detailed Technical Design Report (TDR) in 2001. SLAC in the US has been studying an accelerator technology similar to JLC within the framework of the collaboration for the Next Linear Collider (NLC) [6]. At CERN, very advanced technology for a Compact Linear Collider (CLIC) [7] is being investigated. There has been excellent communication and close cooperation among these activities.

To show what the high energy physics communities in the above three regions aim at in the future, let us quote part of the materials issued by the three organizations ACFA, ECFA [9] (European Committee for Future Accelerators) and HEPAP [10] (DOE/NSF

High-Energy Physics Advisory Panel).

ACFA summarized its conclusion as statements issued on the 18th September, 2001, in which one finds its recommendations:

- "The e^+e^- LC must start operating when the high luminosity run of LHC starts around 2009−2010. The center of mass energy of the LC should be 250−500 GeV where urgent and critical physics is expected. Including its energy upgrade to higher than 1 TeV, the project as a whole is foreseen to be evolved for a quarter of a century."
- "ACFA strongly endorses the plan to construct such a collider in the Asia-Pacific region with Japan as the host, and urges KEK to take initiative to investigate possible and practical form of globalization for the construction, commissioning and operation of the collider."
- "ACFA urges the Japanese Government to arrange a preparatory budget for KEK to pursue an engineering design of the collider, to study site and civil engineering, as well as to investigate the process for the globalization."

An ECFA report, '*Report of the Working Group on the Future of Accelerator-based Particle Physics in Europe*' issued on 21st September 2001, comprehensively covers the whole field of particle physics, but its main target after LHC reads as follows:

- "$\cdots$, the Working Group recommends the realization, in as timely a fashion as possible, of a world-wide collaboration to construct a high-luminosity e^+e^- LC with an energy range up to at least 400 GeV as the next accelerator project in particle physics. The Working Group urges the appropriate bodies to make decisions concerning the chosen technology and the construction site for such a machine soon. $\cdots$"

In the US the Sub-panel on Long Range Planning for U.S. High-Energy Physics under HEPAP published its report in January, 2002, and states in its Recommendation 3 :

- "We recommend that the highest priority of the U.S. program be a high-energy, high-luminosity, electron-positron linear collider, wherever it is built in the world. This facility is the next major step in the field and should be designed, built and operated as a fully international effort. $\cdots$"

It is remarkable to see a perfect coherence of these recommendations on LC. Summarizing their considerations, one can deduce the following basic and common thoughts:

1. An e^+e^- LC is *critical* for high energy physics in the coming decade. Without it we will miss a vital facility to deepen our knowledge of Nature.
2. The LC should come into operation while LHC is active.
3. The first stage of the LC should achieve several hundred GeV energy and the upgrade should be vigorously pushed to reach the TeV energy region.
4. The LC should be planned, constructed and operated under a world-wide collaboration from the beginning.

The first three items are concerned with the physics program. The last one proposes a new policy and directs to introduce a new and efficient structure into the high energy physics community of the world. Not only physics, but also the framework for world-wide collaboration, is entering a new era.

Extensive discussions and studies have already been made concerning possible schemes for such a global-scale cooperation and how they may be reached. Such investigations are being continued by various bodies, such as ICFA [8] (International Committee for Future Accelerators) and the Global Science Forum [13] under OECD. Some of the notable developments in recent years are listed below:

1. On the scientific side, ICFA has been actively discussing various aspects of the future LC project. It has conducted studies both for technical problems and for organizational matters. For instance, the world-wide study for the physics and detectors for future linear e^+e^- Colliders was formed several years ago [11] and has been sponsoring a series of workshops. ICFA launched two work-groups on the "Global Accelerator Network" concept in 2001, whose reports have been posted on the ICFA web site [12]. Also, under ICFA, the International Linear Collider Technical Review Committee (ILC-TRC) was resurrected in 2001. The Committee is expected to submit its report by the end of 2002. In order to proceed in a more focused way, an International Linear Collider Steering Group (ILCSG) was recently created by ICFA to continue these studies more vigorously.
2. On the financing agency side, OECD formed a consultative group including both scientists and government officials under its Global Science Forum (GSF) to help identify issues and possible ways to reach and conduct an international cooperation on a global scale in the future of high energy physics. The Consultative Group (CG) discussed the future evolution of high energy physics, including the priorities set by the scientific communities, and plans for both accelerator and non-accelerator activities. CG also examined relevant organizational and procedure matters associated with future major high energy physics projects. The LC is the natural focus among the topics under discussion. CG reported its findings [13] to GSF in June 2002.

5 Globalization of the Project

The word 'globalization' has become very popular and widely used today. This scheme itself is not the goal of high energy physicists, but globalization is a key element for us to share the opportunities, responsibilities, cost and benefits of our research with LC as extensively as possible.

A glance at its history shows that high energy physics has been keeping an international nature from its birth, because its mission is to clarify the most fundamental laws of Nature and the universe. New discoveries and the results achieved in these research activities must be the common assets of every human being.

Hence, our basic principle is that high energy physics should be pursued independently of any political, national, ethnic, or gender constraints. The opportunity for research has been, and must be, equally open to all scientists in this field, as formulated in the ICFA guidelines of 1971. This should also be extended to countries that have not been on the frontier of high energy physics research. We should consider the next LC project as such that will give a novel and unique chance to realize internationalization and cooperation in our field on a global scale. One can expect that globalization will be greatly beneficial for science, technology and education in the world during the long duration of the LC project. This is one of the most important aspects that the LC project can contribute to the world. In order to establish a partnership with various countries, it is indispensable to understand the cultural differences as well as the wide range of levels in the economical and technological development of each country. This project will therefore help us better understand each other.

The deeper we push in our attempt to understand Nature, the basic building blocks of our world and the forces between them, we need access to ever more powerful 'microscopes' to look in greater detail at ever smaller distance scales. This in turn requires ever higher energy accelerators, which demand higher budget and more human resources. Although it originally started regionally by the European community, the most recent hadron collider, LHC, is being constructed under cooperation on a global scale. Like any other energy frontier accelerators, securing the resources for the construction, commissioning, operation and upgrades of the LC facility is a major issue.

Upon seeing the size of the LC project in Sec. 3, it seems hard for a single nation or a single region to support its entire construction and operation budget. Also, any single region in the world would have substantial difficulty sustaining the required expert human resources by itself.

Since the project definitely requires state-of-the-art high technologies and the help of industries, we have to search in time all of the necessary technologies by collecting all of the feasible technical ideas from around the world.

To meet the technological requirements for the new accelerator, intensive R&D projects are on-going among the three regions by international collaborations. The Accelerator Test Facility (ATF) has been constructed at KEK and operated by an international cooperation. The KEK-SLAC collaboration is developing accelerator elements and a final focus design. The same is true for the development of a super-conducting accelerator for the TESLA project at DESY and the two-beam accelerator CLIC at CERN. While there are several choices for the baseline design, the physics target and the required machine performance are not much different. This is also a reason why the world has reached a common view on the project.

It should be stressed that during the long history of high energy physics, this is the first time to reach such a consensus on a global scale prior to the approval of the project by the governments. Looking at the size of the project, it seems that there would be no other way than to build only one machine in the world. This machine, therefore, should not be isolated and monopolized. The globalization of the project is thus most important, and should play the key role in organizing such a laboratory.

The LC project has to be conducted as a truly global-scale international project that is open to developing countries as well as to developed countries. This is not only because the cost and human resources for the LC must be shared by many countries, but also the enthusiasm for the basic science must be shared world-wide, which will lead to further progress in understanding Nature.

Based on the experiences and developments accumulated so far on the technology for a LC, the time is already ripe to establish an international partnership among countries toward the realization of the project on a global scale.

This global laboratory is along the lines of the current policy of the Japanese government, as outlined in the Science and Technology Basic Law [1995], the Science and Technology Basic Plan [1996], and the Second Science and Technology Basic Plan [2001]. Indeed, we find the following declarations in those governmental documents:

- "The nation should implement necessary policy measures to promote international exchange such as international exchange of researchers, international joint R&D and international distribution of information on S&T, in order to play an active role in international society, as well as to contribute to further progress in S&T in Japan, by intensely promoting international S&T activities."
- "The role of the government is becoming increasingly essential in fulfilling international obligation, with its contribution to the world and all humans, and in promoting public understanding and interest in science and technology."
- "[Japan should] "positively and widely promote international joint research on basic science, which has intellectually creative activities for all people." [It also

should] “work on mega-science projects, including space science/technology and accelerator science through Japan’s own initiative.” [Furthermore, it should] “steadily promote international joint research in accordance with science and technology agreements.”

6 Necessary Features of the LC Laboratory

The organizational structure of GLCC has to be considered from various aspects. Among them, the following are the key features of the new international organization (henceforth, simply called “the Organization”) that have to be satisfied in launching this grand international project:

- **Long Term Stability**
  The Organization must be stable in its relation to the supporting governments given the long duration of over 20 years or more, and the complexity and large size of the project. Governmental support and a solid international legal base must be prepared to assure a long-term commitment from participating countries or regions. The Organization, however, has to be flexible enough to allow short-term decisions in order to quickly respond to the requirements of an efficient operation of the project.

- **Timely Start**
  Because of the strong demand for having the operation of the LC facility concurrent with that of LHC, a fast and smooth start-up of the LC project is of critical importance from a scientific point of view, as clearly expressed in the statements of ACFA, ECFA and HEPAP.

- **Governance**
  As other large international scientific projects, the linear collider facility will be the result of the initiative of a large, international group of scientists interested in this new, advanced tool. In order to respond in an optimal and effective way to the scientific needs, the management of the project must be in the hands of scientists or engineers, assisted by a high-level administrator, who have the full confidence of this group. The oversight of the project will be exercised by the participating governments, possibly through appropriate funding agencies, in the Council and the Bodies of the latter. It is expected that the governments act in the Council after close consultation with their national particle physics communities.

- **Equal Opportunity**
  The partners involved in the project should be treated on an equal footing regarding scientific activities, although there will be different levels of contributions

among them. This includes: as equal access to facilities as possible, an equitably equal role in the decision-making process, and an equal opportunity to access scientific outcomes of the project.

- **Attractiveness**
  For the LC center to remain a landmark of science for a long time, it has to be widely accepted by the general public. Especially, it must be attractive to the younger generation scientists not only in high energy physics but also in other fields of research, and to industry and politicians. Harmonious development in science as a whole must be seriously considered. The application of the new technologies developed in the linear collider project must be encouraged. The LC project must be conducted under careful and continuous reviews by the science communities.

It should be noted that the primary objective of the Organization is to build an accelerator facility with specified energy and luminosity and to carry out a successful research program. Consequently, the following considerations need to be taken into account:

- When the construction of the LC is started by the Organization, a clear choice of the technological design for the LC has to be at hand, and its total construction and operation costs have to be known, and agreed upon between the partners.
- When the construction of the LC is started by the Organization, clear agreements on the cost and work sharing among the international partners have to exist. The contributions pledged by the partners need to satisfy the perceived resource requirements.
- Some of the details will require negotiations which may have to continue after this Organization is formed. However, a set of definitive agreements need to be in place by the time that the actual construction of the LC begins.

In the management and operation of GLCC, the following matters must be guaranteed:

1. **Continuity of the design, construction and operation**
   One team with a strong and stable nucleus around the Director must have the responsibilities for the engineering design, and after approval, for tendering, production, construction and then operation.
2. **Legal status**
   GLCC must have an appropriate legal status, within the host country and between participating nations or regions, which allows settling of the following issues:

- Immigration/visa/residence issues.
- Tax issues.
- Property issues.
- Safety issues.
- Disposal and dismantling.
- Proprietary issues.

3. **Transparent management**
   The LC center has to handle a complex management involving international resources (both funding and human) for a long time. The management and decision-making process must be completely transparent at all levels of its managerial structure. This is particularly important in GLCC, where the goal can be achieved only with long and continuous efforts of all the participants.

4. **Efficiency**
   The administration and management structure of GLCC must be designed to optimize the efficiency of the project. To make the tendering open to the world is one of the clear prerequisites.

5. **Health of participating institutes**
   The investment by all governments in the new project will bring along the expectation of reducing their investments in the local laboratories, and probably change the scope of those institutions. A scheme for participation of the staff members of the contributing laboratories will have to be devised to keep these laboratories active and to provide support through high-quality technical personnel to the new laboratory.

7 Possible Schemes for the Construction and Operation of the LC

7.1 Possible Schemes

This section discusses possible schemes for the Organization that would be responsible for the construction, operation and upgrades of the LC. In the context outlined in Section 6, the Committee considered the following two schemes as representative possibilities:

1. **Extension of an existing laboratory or institute**:
   In this case, an existing laboratory carries the bulk of the responsibility for con-

struction, commissioning and operation of the LC facility. The extended laboratory needs to accommodate the functionality of the Organization that is required to effectively execute a major-scale international collaboration. In the case of Japan, the laboratory to be extended would be KEK.

2. **Creation of a new international laboratory**:
   In this case, a new international organization is formed and becomes responsible for the construction, commissioning and operation of the LC facility. Thus, the creation of this laboratory needs to be based on an international agreement. In the case of Japan, GLCC is formed as legally separated from KEK, although KEK will be one of the primary collaborating institutes.

In the following, the rationale for these schemes as well as possible advantages and potential issues are summarized, as examined by the Committee.

7.1.1 Extension of an Existing Laboratory

The extension of an existing laboratory is considered appropriate when the host country (or the host region) commits a substantial fraction (for instance, more than three quarters) of the construction cost. In this case, the bulk part of the budget management work becomes a single-nation (or single-region) issue, and it is more appropriately handled in the framework of a national (or a regional) institute.

However, even in this case, because of the unprecedented magnitude of the technical complexity and the required amount of human resources, an international collaboration of a major scale will still be inevitable in the construction of the LC facility. Therefore, the globalization of the project in many of its aspects is necessary and essential. For instance, unless managed with adequate openness in many of the decision making processes, an excessive dominance of the host laboratory or the host nation could produce adverse effects against a healthy, long-term international collaboration at the LC facility.

The host laboratory, in the case of Japan, will be KEK (or its future incarnation). In this case, a LC center would be created as a new branch of KEK, and the center will be controlled by its project director who would report to the director of KEK and an international steering body. The remaining contributions necessary to construct the accelerator would be requested from abroad, as was made for the construction of HERA at DESY. In the areas of human resource and scientific management, provisions must be made to support this international collaboration. This, in turn, will have a major impact on the ways that the host laboratory (e.g. KEK) operates. The government needs to be put on notice of this issue, should this scheme be pursued seriously.

If the LC project is fully supported by the Japanese government as an extension of KEK, with a full understanding of the issues discussed above, this scheme can be realistic. It is expected to incur a relatively small lead time for the formation of a new management structure, since a prototype management structure already exists in the form of the existing laboratory. Consequently, it may be capable of a "jump-start", if an adequate budget is approved in a timely fashion.

However, the Committee feels that this scheme of extending KEK may be less attractive for Japan, because this form does not lend itself very well to making a contribution to the globalization of science. This can be not optimal in the light of seeking long-term commitment of expert human resources world-wide[2]. In addition, at this point in time, the Committee also feels that it is perhaps too optimistic to expect a single nation to support more than three quarters of the construction fund for the LC in a timely way.

Therefore, in subsequent studies, we will not take "extension of the existing laboratory", supported dominantly by a single nation (or few nations), to be our first choice to pursue. We restrict ourselves to maintain this scheme as a potential alternative, should the governments find this to be a better approach for reasons to be determined in the future.

7.1.2 Creation of a New International Laboratory

The creation of a new international laboratory is considered more appropriate, when a number of partner nations bring in equitable amounts of financial contributions. In this case, the budget execution by the Organization needs to be made more directly accountable with respect to the funding agencies of partner nations. Also, some built-in mechanisms need to be incorporated in the Organization so as to ensure that the partners are treated on an equal footing. An international laboratory is considered to be a suitable entity to fulfill such requirements. Some of the specific issues will be the subject of discussion in subsequent sections.

The underlying principles of the Organization are as follows:

- The laboratory is supported in cash and by in-kind contributions from a number of nations who agreed, through government-level agreements, to participate in the construction and operation of the LC facility and research work there.
- The laboratory management is executed by its staff members who joined the Organization from the member nations (and elsewhere).

[2]An exception may be the restructuring of KEK to renew it as a fully international institute. In this case, the process is almost equivalent to the creation of a new international laboratory discussed in Sec. 7.1.2.

- The laboratory incorporates a mechanism (council) so that all aspects of its scientific, administrative, and management activities are overseen and reported to representatives from the member nations.

When such a laboratory is created in Japan, a natural assumption will be to create this laboratory as a new, international legal entity, which is separate from KEK. The latter continues its function as a national laboratory being one of the contributing/participating laboratories to GLCC, and remains the supporting laboratory for the Japanese high energy physics community which carries out the detector and accelerator work required for the construction and R&D for upgrading, which are the Japanese contributions to the global lab, and which cannot be delegated by universities. The construction and operation of the LC will be under the full responsibility of this new international laboratory, GLCC.

On the other hand, when managing matters related to civil engineering or interactions with municipal governments concerning the living conditions of the staff in Japan, the assistance extended by KEK could be very helpful, particularly in the early stage of the project. There would be many other areas where contributions and assistance by KEK are of special value, if desired by GLCC, in terms of smoothing out the construction process of the LC facility, due to the local expertise accumulated at KEK.

Therefore, although the project is a fully international one in this case, one should consider special roles of the host country and KEK for a smooth start of the project.

7.1.3 International Organization — Committee's Recommendation

After some deliberations the Committee concluded that it should recommend the creation of an international Organization, which is based on treaty-type agreement among the participating governments, by the time of the beginning of the construction of the LC.

As discussed in Sec. 7.1.2, this scheme is expected to be capable of satisfying all of the desired features as laid out in Sec. 6. It should also be pointed out that the work that is required to establish this Organization should not incur significant additional time if the tasks are carried out in parallel. For instance, the process of negotiating and settling on the agency and government agreements on the contributions, the completion of R&D for a rational technology choice and a solid cost estimate will at least take as long as the preparation of the government-level treaty-type agreement. Once the agreement is signed, its ratification is expected not to take more than several years[3].

The following observations are noted:

[3] For instance, in the case of CERN it has taken about two years.

1. The most important mission of the LC laboratory is to successfully build an LC facility and operate it. This requires an accurate knowledge of the project cost (both financial and human resources), its sharing among the partners, and the commitment by the partners. It would be extremely problematic to start the construction of the LC while the entire sum of the contributions by the existing partners is known not to satisfy the total needs, or the commitment by some of the partners are not based on solid approval by their governments and the relevant parliamentary bodies. Therefore, the long-term, financial commitment by each partner will have to be backed up by approvals by the governments before the start of construction.

2. Independent of organizational models, parliamentary approval, rather than just an exchange of Memorandum of Understanding (MoU) between agencies or governments, will be mandatory to launch the large scale international project and to share a substantial amount of funding. This certainly is the case for Japan, and is likely to be so in other countries. Furthermore, the LC project needs partners not only to participate, but also to establish the international Organization of the new laboratory. Consequently, a well defined scheme of international cooperation including the organization will have to be prepared by government-level negotiations between participating countries or regions, and the inter-governmental agreements will have to be approved by parliamentary bodies.

3. If the consensus to be formed among the international community of high energy physics is firm enough to convince the funding agencies and the legal bodies to commit a large-scale expenditure, then the creation of an international Organization to conduct the project based on treaty-type international agreements may not be too time-consuming. An estimate quotes this treaty process to be as short as 2–3 years.

4. Under special circumstances, some nations may prefer to contribute to an international Organization for the LC as a group or through another representative body, such as CERN, rather than signing independently on the treaty-type agreement. Some nations may prefer to let their respective research institutes sign on the laboratory-level MoU's (Memorandum of Understanding) with the LC Organization. All of these special cases may be handled adequately if the international LC Organization possesses an appropriate legal status.

For these reasons, in the rest of the discussion we primarily consider a treaty-based international laboratory, unless otherwise stated. It is to be established by joint efforts of governments, scientists and engineers around the world. It is noted that this laboratory, if created, would be the first international laboratory on a global scale for particle physics.

An idea of forming a world-wide collaboration as a prototype of the LC laboratory among those laboratories who are interested, is worthy of further pursuit, particularly in light of offering a very useful platform for co-examining many of the issues associated with a full-scale collaboration in great detail. It should also help accelerate the R&D process and to develop engineering designs of the LC facility. Such a world-wide collaboration is also considered to be a key to demonstrate the feasibility of the global-scale cooperation to governments and to the public, which surely is highly desirable to accelerate the governmental approval process.

Note that this world-wide cooperation should be considered as an intermediate stage of the process, rather than an ultimate form of the Organization that is responsible for the construction and operation of the LC laboratory, since such a joint project among laboratories may not be able to assume long-term funding and provide the stability that is required to complete the construction of the LC, operate it over many years and, eventually, upgrade it. The scheme is further discussed in Sec 8.3.

7.2 Possible Legal Basis of the Laboratory and Relation between the Laboratory and Countries or Regions

The legal status of the laboratory is defined by a government-level agreement among the participating nations through a treaty or an equivalent contract, and it needs to comply with relevant international laws. A notable example is CERN, although it was conceived and created as a regional international organization. The "treaty" has to define the following items:

1. Term of the Organization, with provisions for possible extension.
2. Organizational structure of the laboratory, including the functions of the director/the directorate, Council, and their nomination and appointment processes.
3. Accession and termination processes of the membership for the participating nations.
4. Representation of funding and supporting bodies from each member nation/region. Provisions for group participation, etc.
5. Legal status of the laboratory staff.
6. Application of, or exemptions from, local or domestic laws concerning taxes, insurance, and operation licenses for equipment.

Some additional considerations are noted below:

- How the financial, in-kind and resource contributions (facility or seconded personnel) are to be assigned to and balanced among the partner nations.

  The structure of the Organization has to be designed so that it can cope with the participation by a number of nations in which various funding/support schemes exist for science and technology. The representative(s) of each country/region or group of countries should be chosen appropriately. It should also be noted that the forms of the contribution or participation by partner nations may be changed during the course of the project. Reevaluation of the form and approvals of new partners must be possible in a flexible way.

- How the Organization handles cash funds.

  While the bulk of the contributions by the participating nations may be made in the form of in-kind contributions, a common fund has to be established by cash contributions both in the construction and in the operational phase. Especially in the operational phase, the fraction of the cash contribution will be significant.

  The Organization should be allowed to obtain loans from banks with the agreement of partner nations. It is mandatory that the global lab be authorized to award multi-year contracts and budget holding with partner nations and the Japanese government.

7.3 Basic Structure of the Laboratory Management and Role of the Director

Fig. 2 gives a possible structure of the laboratory based on an international Organization. It shows the basic topology, as drawn from an example seen at CERN. Basically the Organization consists of a governing Council (or Councils) and the Director (or Directorate), who is responsible for managing the divisions within the laboratory for handling scientific, technical and administrative matters. In addition, various types of advisory bodies and ad-hoc panels may be created to assist in operating the laboratory.

7.3.1 Director

The Director (Directorate) is the one who is responsible for execution of the project and the day-to-day management of the laboratory with the resources that are made available for GLCC. Because of this responsibility, the Director is given the authority over resource allocation within the laboratory. The Director also appoints the executive managers within the laboratory for sections of administrative tasks and for science/technology groups. These key personnel should be staff members of the laboratory.

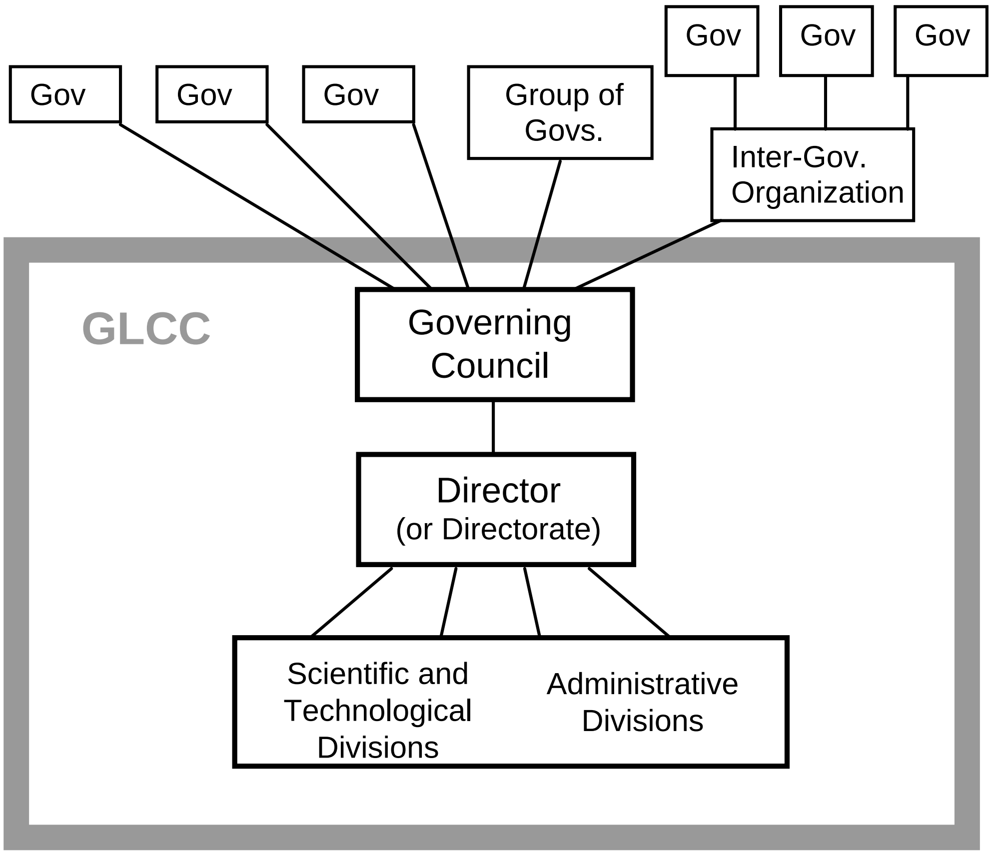

Figure 2: Possible organization chart of the LC laboratory.

The Director is also expected to take the initiative to improve, strengthen and extend the collaboration between major laboratories around the world for the construction, operation and upgrade R&D.

7.3.2 Council

Since the resources made available for GLCC are contributed by the participating nations, there has to be a platform where representatives from these nations determine the strategy and key managerial and administrative policy issues to be executed by the Director. The main objective of the Council is to serve this purpose.

The members of the Council would consist of termed representatives of the funding bodies of the participating nations or regions and prominent scientists who are appointed by the funding bodies and being part of the national delegations[4]. Representatives of

[4]The Council may also seek scientific opinions of Advisory Committees which consist of prominent scientists who are selected by the Council ad personam.

the users of the GLCC facility should also be included in the Council.

The tasks of the Council will include the following, which are to be done in accordance with the charter of the Organization:

- Appoint the Director of the laboratory and hold the Director accountable. The term should be defined in accordance to the charter of the Organization.
- Approve the appointment of key personnel, as proposed by the Director, in accordance with the charter of the Organization.
- Overview the scientific programs, policies and procedures of the Organization.
- Make critical decisions on the assignment of contributions by participating nations, and approve the budget plan that is proposed by the Director.
- Approve the project plan, including the upgrade program, that is proposed by the Director.
- Make decisions on the accession and withdrawal of membership.

Member nations who joined the construction, operation and management of GLCC are on "an equal footing". However, this does not necessarily mean that everyone has the same one vote in all decision-making processes. The voting protocol in the Council could depend on the issues to be decided. Since the management of scientific matters of the laboratory should be based on a consensus of the scientists who support the project, most decisions would be made by a majority of votes with equal weight. However, for issues related to the budget, or issues related to external human resources, the Council may have a voting procedure with appropriate weighting in proportion to the contributions by the members.

7.3.3 Issues on Contributions

It should be noted that the participating nations, with varying standards of living, may bring in contributions in various forms. Equitable procedures need to be developed to evaluate these contributions based on all aspects, such as human resources, raw material, end-product or equipment, running costs and the common funds.

Issues of "premature withdrawals" of early participants will need careful examinations. Generally, the charter of the Organization should be written such that withdrawals of participating nations during, at least, the critical periods of facility construction and commissioning be made highly difficult. In addition, it is essential that a fairly advanced warning be given to other nations when a member has to withdraw from the project.

While the project must be fully open to new participations at any stage of the project, the "late comers" need to respect the investment of the early participants in a fair manner. The charter will likely be made such that additional initial contributions are requested from those nations which decide to join at a later stage of the LC project.

7.4 Role of Host Country, Local Government (Prefecture), and KEK

The successful operation of the LC facility requires a broad range of services in addition to the design, construction, commissioning and operation of the accelerator. Therefore, there are special roles for the host country. The help of the local, national high energy physics community and the high energy laboratories (KEK in the case of Japan) will be indispensable and will thus give special responsibility to the host country.

7.4.1 Host Country; Japanese Government

The relation between the GLCC and the Japanese government must be clearly defined by treaties. The Japanese authorities could be responsible for the following issues:

- Approval of the project as the hosting country as well as a participating country.
- Providing land for GLCC.
- Providing appropriate legal support to establish and maintain GLCC in Japan.
- Assignment of the representative institute(s) as a supporting institute(s) to help GLCC.
- Making agreed-upon contributions to the project through KEK (and other domestic institutes) for the construction and establishment of GLCC.
- Providing assistance to support the GLCC staff, users and visitors, including their families.

7.4.2 Relationship to Prefecture/Municipal Government(s)

Support from the local government(s) is essential for the project. The following items are within the responsibility of the prefectural administration:

- Cooperation to promote the project as a major development of the area. Preparation and execution for the environmental assessment as well as negotiation with local residents should be made with close collaboration between the prefecture, GLCC and KEK.
- Emergency service, such as police and fire brigade.
- A part of the safety regulation is under the auspices of the local government.
- Cooperation with GLCC for daily-life requirements for the GLCC staff, users and visitors, as well as their families.

7.4.3 Role of KEK

Although the model laboratory is a fully international one, and owned by the participating countries, at least one Japanese institute should give major support to help GLCC during the initial phase of the project.

At that time, the already existing infrastructure at KEK should be efficiently utilized, for example the test facility, storage, equipment, and other user facilities. The knowhow accumulated at KEK for the smooth startup of the project and machine construction/operation in Japan, both in administrative tasks and in engineering tasks, must be transfered to GLCC as much as GLCC requests and should be effectively used.

Further, KEK is expected to contribute as a central body for Japanese participation to GLCC. This will be the most important supporting role of KEK for GLCC. A major part of the activity in high energy physics, both in the accelerator and the physics sections at KEK, must be the GLCC project. The majority of the accelerator experts are expected to join GLCC as staff, seconded, or guest scientists. The migration should be made gradually and smoothly.

It is important to maintain R&D activities for accelerators including the next-generation machines. KEK should keep acting as the central body of such R&D in Japan.

7.5 Relationship between GLCC and the Users/Physics Communities of the World

For the successful operation of the project and optimization of the physics output, opinions from users who take physics data and analyze them should be appropriately reflected in the laboratory management and project plan. For this purpose, the user community should have representatives in the GLCC council in addition to the scientists in the delegations of the participating countries.

ICFA, ACFA, ECFA and HEPAP are considered to be scientist organizations driven by consensus among the world/regional HEP scientists. Such organizations should give advice to the project. Their opinion may be given in an external review committee (Scientific Advisory Committee) to the GLCC. Their participation is particularly important for the major upgrades, to collect new partners, and to adapt the structure of the laboratory to a long term road-map of particle physics.

7.6 Human Resources

The GLCC Director employs/promotes key staff members (division leaders). There should be no limitation by nationality. To select the best persons, the Director forms a search committee in consultation with the Council. The key staff members need approval by the Council.

The relationship between the nomination of the staff and the contributions of participating nations is an issue. We recommend that appointments be based on his/her expertise and not on any quota by institute or nationality. The staff members under the division leaders are nominated by the leader with an internal search committee. The appointment is made by the GLCC Director.

Since the total amount of human resources with sufficient expertise for the design, construction and operation of the accelerator cannot be expanded as required, external human resources will be necessary from the participating institutes, including KEK, and companies. In this case, the GLCC Director asks the external institutes or companies for seconded personnel. The nominations of seconded personnel are made by the management of the external body, and appointed by the GLCC Director. Contracts are made between the GLCC Director and the management of the external body.

GLCC should provide seconded staff members status equal to the lab's own staff as much as possible. The Organization should define the status of the seconded personnel with fixed contracts with their home institutes. The contract should also define the terms, job descriptions, benefits, and evaluation measures of his/her achievements.

The issue with human resources is critical not only for the GLCC project, but also for the participating institutes for their own projects. The sharing of the human resources between GLCC and the existing laboratories must be carefully designed in the long-term planning of both GLCC and participating institutes. Such global aspects of long-term sharing of the human resources must be pledged among the participating countries and regions.

7.7 Role and Relation of Major Laboratories and Other Participating Institutes

A strong cooperation between the participating institutes or science agencies is indispensable. A smooth transfer of human resources between existing laboratories and GLCC is necessary. The agreements among the participating institutes must include ones concerning the share of human resources, in addition to the maintenance responsibilities concerning in-kind contributions.

Another key issue is sharing of the responsibility for the R&D projects towards the potential upgrade for higher energy and luminosity. The upgrade has to be considered within the scope of the project from the early stage of the design. The agreements among the participating institutions must also cover the R&D for the upgrade.

8 Recommended Way to Proceed

8.1 Goals

The creation of GLCC and successful execution of the LC project therein will require concerted efforts among multiple segments of the world community, not limited to research scientists and engineers. The subjects of the next series of efforts may be summarized into the following:

- Establish an agreement among the scientists and engineers of the world concerning the baseline technology, and the central parameters of the machine,
- accelerate coherent efforts on the R&D, engineering design of the accelerator and relevant test facilities by sharing the common assets, knowledge, budget and infrastructure,
- demonstrate to governments that an international cooperation by this international HEP community can be successfully implemented, and
- obtain governmental support through the promotion of the project in public and close communication with governmental bodies.

These efforts should be made in such a way that a world consensus eventually emerges on work sharing, fund sharing, details of the GLCC Organization, as well as the selection of the site for constructing the LC facility. Once a clear consensus and design of the machines are established, the process to form an international agreement by treaties or something equivalent may take as short as 2–3 years.

8.2 Ongoing and Near-Future Efforts

There have already been a number of activities in the world HEP community on various aspects of world-wide efforts towards LCs:

- **Technology review:** The Technical Review Committee (TRC-II) was resurrected by ICFA in 2001. It has been active as a review forum, where accelerator physicists from around the world share the ideas, prospects and challenges on various LC technologies. The TRC-II will complete its mission by submitting its report by the end of 2002. However, the working relationship that is growing in this process among the accelerator physics communities is a valuable asset for forming a global-scale collaboration for the LC facility.
- **International coordination:** ICFA has recently (2002) taken an initiative to form an International LC Steering Group (ILCSG). The primary task of the ILCSG is to promote the construction of the LC through a world-wide collaboration, and to report to ICFA. The ILCSG will give particular attention to outreach, science, technology and organization of the LC project. Discussions on technical issues will continue under one of its subcommittees, based on the work done by TRC-II and elsewhere. The ILCSG will also attempt to address a broader range of issues, including models of the organizational structure, suitable for the construction of the LC facility, based on international partnerships.
- **Regional coordination:** Parallel to the ICFA's activity, each region of Asia, Europe and North America is forming its own regional steering group which will address similar questions from their own standpoint. Although they are created independently, there will be links to the ILCSG, and they will cooperate among themselves.

It is our projection that the discussions could start with technical matters faster, and then gradually move on to legal and political issues with the participation of government officials. A solid agreement on the former is expected to offer a firm basis for more complex negotiations on the latter. However, in some cases, the exchange of opinions on these subjects may proceed in parallel:

- **Discussions involving government officials:** As mentioned in Sec. 4.2, the Consultative Group (CG) on High Energy Physics under the Global Science Forum (GSF) of OECD was formed in 2000. There, the representatives of relevant agencies and scientific community jointly discussed the future research programs in High Energy Physics. This group, by observing the consensus among the world high energy physics communities for an LC, studied a possible organizational form for a global collaboration, and identified many issues that need to be addressed. It submitted a consensus report in the summer, 2002 [13].

Once the merits and issues of the global collaboration are established as a consensus, the next step will be to develop practical solutions that are agreeable to all, both politically and scientifically. A forum where government officials and scientists of all interested countries can discuss these issues needs to be formed[5]. It is our opinion that very careful examinations must be given and clear definitions should be laid out concerning the membership of such a forum and its relationship with ILCSG or regional steering groups, as well as relevant agencies and executive branches in the interested nations. It should also be recognized that some of the matters that are suitably dealt with by decision-making officers in one country may require the involvement of political representatives in another country.

8.3 Pre-GLCC

Section 8.2 mentions the numerous activities that are currently ongoing towards an LC. However, the world does not yet have a body in order to unitedly pursue the technological, organizational, political and legal matters, with a clear goal of forming a consensus and with a suitable decision making power at the same time. Hence, we propose to form the "Pre-GLCC" (Pre-GLC Collaboration or Pre-GLC Center) as the body that is responsible for carrying out all practical tasks on related matters, as well as a common forum for the people who work together as a world-wide team.

Several forms of international collaborations on accelerator R&D have been quite active at TESLA, JLC/NLC and CLIC. An important responsibility of Pre-GLCC is to coherently push the world efforts one more step ahead, based on the achievements marked by these teams. This has to be done at both the technological and organizational fronts, with a clear intention of the joint construction of a linear collider. Obviously, close communication links, open sharing of technical information, and the cultivation of a common, collaborative spirit among various layers within the participating laboratories, will be of critical importance that requires conscious efforts by all who are involved.

The following points are noted:

- **Membership:** The fastest path is to form Pre-GLCC as an MoU-based collaboration, among the major HEP laboratories (BINP, CERN, DESY, FNAL, IHEP, KEK and SLAC), with an endorsement of ILCSG. The initial membership of Pre-GLCC would be the representatives of laboratories and HEP communities world-wide, who are engaged in linear collider development in a major way, and their physics and accelerator teams. Participating laboratories in this collaboration will create local headquarter offices to carry out the necessary tasks,

[5] In fact, the follow-on activities has been started by the Consultative Group on High Energy Physics under GSF of OECD.

e.g. regional coordination of technical and organizational research activities as part of this collaboration.

While the main parts of the initial activities of Pre-GLCC may be adequately managed by a collaboration of interested research institutes, participation of government representatives with suitable policy-forming authorities will become essential in a later advanced stage of Pre-GLCC. This is because Pre-GLCC aims to form a set of prescriptions not only on the technological matters, but also on organizational, legal, and political matters as well. Finally, the Pre-GLCC should also allow the later participation of laboratories, which may not be able to join in an early stage of the collaboration.

- **Technology choice:** At this moment there is an ongoing, world-wide debate on the technology choice for the main linacs, *i.e.* the room-temperature vs. superconducting technologies. In the traditional spirit of HEP collaborations, if the world community agrees that all of the talented and capable scientists need to work together for a common goal after all, Pre-GLCC should be formed before, rather than after, the question of technology choice is settled. There, Pre-GLCC should assume the responsibility of settling this technology choice issue in a congenial and agreeable way. This has to be done through fair reviews on the potential of the technologies, the availability of the resources, and the suitability for short-term and long-term prospects for physics research.

- **R&D towards engineering design:** The Pre-GLCC should assume the responsibility for coordinating and promoting the world collaborations on the advanced stage R&D of LCs. Of particular importance is to produce a thorough engineering design of the LC with a full understanding of the construction and operation costs as well as future upgradability, which can withstand critical peer reviews of accelerator experts world-wide.

- **Organizational matters:** Although Pre-GLCC is *not* GLCC, it is expected that many aspects of the organization of the Pre-GLCC can serve as a prototype for that of GLCC. This is particularly so in the areas related to the organization of technical groups. With active participation of government representatives, more thorough reviews on legal issues can also be conducted. The Pre-GLCC serves as a platform for such reviews and discussions, with all the necessary participants readily available under an MoU agreement.

  The evolution of the management structure of Pre-GLCC, during the course of the joint efforts, should lead to something similar to what is envisaged for GLCC. At some point, the participation of government officials of suitable levels will allow the formation of a Council, which appoints the Director (Directorate) of Pre-GLCC, and which acts as a link to the relevant agencies of governments for the member laboratories. There, a good mixture of scientists, diplomats and government officials experienced in the management of big science projects have to work together towards the establishment of a real laboratory to start construction. It is natural to consider that this top management layer of Pre-GLCC be eventually transferred to the initial Council of GLCC, which appoints its first Director (or Directorate).

Issues concerning the choice of the GLCC site may well be beyond the scope of Pre-GLCC, since the authority over decisions of this type naturally belongs to the executive branches in the governments of the participating nations. However, Pre-GLCC should assume the responsibility for producing critical technical inputs for this decision-making process as well.

In all of these activities of Pre-GLCC, members of the ACFA HEP communities, including the Japanese, should join as active participants together with colleagues from North America, Europe and elsewhere.

Based on the matured LC technologies and the organizational scheme that resulted from Pre-GLCC, together with the selection of the GLCC site, the decisions on practical work-sharing among the participating nations at GLCC are expected to be relatively straightforward.

9 Important Issues to be Solved

This section summarizes the major issues to be solved in establishing the new international organization or laboratory. Some of these have already been discussed in Sec. 7. Here, we summarize these in two categories: one related to the organization scheme and another concerning the working and living conditions for scientists, engineers and their families.

9.1 Organizational Issues

9.1.1 How to Share Contributions

A scheme to integrate the major systems contributed in-kind from off-site laboratories has to be worked out. The dynamic interactions among them are not trivial and need further investigation.

9.1.2 Responsibility in Operation/Maintenance and Ownership

Some of the equipment would be prepared by common-fund money contributed from various countries. Such systems would naturally belong to the laboratory, itself. However, a large amount of in-kind contributions is expected, for which appropriate ownership should be defined. There are two ways:

- All equipment contributed by partners is given to the laboratory.
- Each piece of equipment belongs to each partner who contributed to it.

The most efficient way depends mainly on how we share the in-kind contribution and the tasks for the maintenance and operation. Participating bodies preferentially contribute in-kind, complete systems with a minimum of interfaces to other systems. Groups/institutes, who deliver large components or systems are responsible for the design, construction, delivery, functionality, local assembly, and later on the operation and maintenance of these systems. However, since the accelerator needs a coherent, perfect integration and operation of all systems, the whole system must be fully controlled by the management of GLCC.

Although it is an issue which has to be investigated further, the committee believes that the first option concerning the final property of the contributions should be preferred in order to effectively establish full control by the GLCC management.

9.1.3 Seconded Personnel

As described in Sec. 7.6, there is an issue to be considered concerning the seconded persons from participating laboratories and institutes. Their salary or promotion is not explicitly under the control of the GLCC management. This may weaken the motivation of the seconded persons, and may make it difficult for the GLCC management to control these people. Therefore, a clear framework for evaluating the work of those people must be formulated.

9.1.4 Remaining Issues

There are a number of issues that need to be considered in the process of the detailed design of the organizational structure of GLCC. Some of them need negotiation with the national and local governments, concerning:

1. Intellectual property,

2. Procurement practices,
3. Liability,
4. Import tax and VAT,
5. License for operation of cranes, forklifts and other safety-related matters,
6. Third party liability, and equipment insurance,
7. Provisions for the dissolution of the organization.

9.2 Working/Living Conditions

The number of people related to GLCC will reach several thousands after the facility is completed. A significant fraction of them would be foreigners speaking a variety of languages, though a very large fraction will speak an international form of English. They will also be eager to learn some Japanese in order not to be cloistered within the "Global Village" surrounding GLCC. There have been good experiences accumulated at KEK and other major laboratories in the world to cope with large-scale international projects. The GLCC project must inherit the experiences and solve the remaining issues. The Japanese government, local government and GLCC must provide appropriate and attractive living conditions for its staff, visitors, and their families, which is one of the major tasks of the hosting country, as noted in Sec. 7.4. In the planning of the project, it must be well understood that there are a variety of cultures and living styles in the world.

Fortunately, in its Science and Technology Basic Plan the Japanese government has already planned to create "a better environment for strengthening international activities in science and technology in the world, promoting the appointment and acceptance of foreign researchers by, for instance, enhancing Japanese language training, building/improving accommodations for foreigners, and providing opportunities for education and cultural activities for the families of foreign researchers."

There are a number of requirements concerning the working/living conditions for those who work for GLCC, visitors and accompanying persons, such as:

- Health and accident insurances,
- On-site/off-site transportation,
- Housing,
- Hospital, school, kindergarden and nursery,

- Visa and work permission for accompanying persons (including non-traditional family members.),
- Finding jobs where accompanying persons can make good use of their skills, know-how, cultural heritage, and expertise,
- Interface to religious opportunities,
- Local recreational facilities, and
- Educational program for students.

We recommend the following specific measures to implement the GLCC project.

Interface Office

It is extremely important to have an Interface Office sufficiently staffed with local people who are fluent in foreign languages, especially in English. They should teach the newcomers about many facets of life in Japan and in the local area, while helping them to accomplish everyday tasks. These staff members must have a personal understanding of what it takes to live and work for a prolonged period in at least one other culture besides Japan.

There should also be courses on Japanese language, culture, and history so that people become able to take a trip to another part of Japan, briefly tell strangers about their work and life, get a car fixed, go to the doctor, and understand Japanese cultural practices. Also a 'lending library' with materials on Japanese culture, history, travel information would be helpful.

Finding Career Opportunities for the Researchers' Partners

An important issue for the local area would be to learn how to find appropriate work opportunities for these foreign 'dual career' couples. This is already a serious issue at major laboratories, and any future global laboratory must have ways of solving this problem. This is not simply an issue of offering work permits and ordinary jobs; there must be career opportunities, too, for all people with expertise outside the fields pursued at GLCC.

Additional resources and services

Many other resources and services will be needed, in addition to those already described in this section. They will need easy access to the national government's immigration office services for getting visas and work permits for themselves and their partners. Also, they will need housing and a transportation system, bilingual schools at all levels for their children, medical care, as well as health and accident insurance.

10 Conclusion

The committee studied different possible models for the organization of a Global LC Center (GLCC) taking into account the estimated scale of the resources and time span for the construction, operation and upgrading of a TeV-scale electron positron linear collider. Among many requirements at different levels, firm commitments of the participating partners and their stable support throughout the project are critical, while flexibility for the scientific program is important and a timely start is desired. Regarding the organization, because of the nature of the science pursued, it is important to provide openness to anybody who is interested. The management of the organization must be clear and transparent.

Two possibilities for the cooperation scheme have been worked out considering the above requirements. One is the extension of an existing laboratory in which the host country takes over a major fraction of the construction and operation costs. The other is the creation of a new globally international laboratory in which the costs will be appropriately distributed among the partners, while the host is expected to contribute the largest sum. Because these are extreme cases of the opposite ends, an intermediate model was also considered. That is, some type of joint venture of interested institutes with the purpose to construct and operate a LC. Although this model was not favored because it lacks long-term stability, it can be useful to initiate a large-scale international collaboration to prepare for the desired establishment.

It was considered to be extremely doubtful whether Japan or any other single country in the world would finance such a multi billion-dollar project as assumed in the extension model though a serious attempt should be made to test such a possibility. It is also unlikely for this model to secure enough human resources with necessary expertise without substantial international cooperation.

For several reasons, creating an international laboratory dedicated to the LC project and open to all high energy physics communities world wide is the preferred solution. A laboratory based on an international treaty can secure financial support and stability over the duration of the project. It is recognized that the time needed to arrange a treaty-based agreement will not be longer than that needed for the parties to reach a consensus over the details of the project, which are required for any international cooperation involving a large financial commitment over many years. Such a laboratory could serve as a center of excellence in Asia and have a considerable impact on the whole world. For Japan, it will be very attractive to host such a laboratory, and this would be in line with the official science and technology strategy.

In order to start a coherent and vigorous effort toward the desired solution, it is recommended that a Pre-GLCC (Pre-GLC Collaboration or Pre-GLC Center) be initiated, which has a similar structure, but based on MoU's of interested laboratories, to conduct the necessary R&D for the accelerator, and to study the details of the organization. In due time, government officials are required to be consulted concerning the activity.

One important point is the role of the host. The project will not only bring a large benefit, but also a large responsibility to the host country. It is a major challenge for Japan to provide the necessary infrastructure for the facility and to prepare the necessary accommodation and living conditions for a large number of collaborators with their families. Until its birth, or even at an early stage of the new organization, KEK may need to take a substantial role to handle these problems. Although KEK remains as one of the participating laboratories, it may go through a major change in its structure and the way it operates.

In conclusion, this committee considers that the creation of a new treaty-based international laboratory is the best way to ensure its long-term stability and clear legal status in order to construct and operate the LC. An intermediate step should be taken by starting a Pre-GLCC in which any interested laboratories can join and solve the technical and scientific issues to obtain a consensus. In parallel, it can also prepare for GLCC by cooperating with government officials to work out an agreement on its final form.

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B History of the Activities of the Committee

The JLC globalization committee was created in July, 2001 and conducted face-to-face discussions three times at KEK. In order to prepare material for the meetings and to summarize the discussions therein, the writing sub-committee met several times before and after each committee meeting. Including the drafting work for the report, the writing sub-committee had altogether about 30 meetings. Many discussions have also been made via e-mail communications in between the meetings at KEK. The topics of the discussions for each meeting are described briefly:

- First meeting November 19, 2001

  1. Introduction of the members and a short presentation of the background by each member
  2. Introduction and classification of the given mandate into two categories:

     a) those which depend on the model of the organization

     b) those which are independent of the model

     Further issues were added to the lists by the committee members.
  3. Introduction of the JLC project and the activities within ACFA
  4. Review of the existing models for international cooperation in the field of big science.
  5. Discussion on the possible models for JLC based on the three typical models, which were picked up by the writing committee for consideration:
     - Extension model
     - Joint project model
     - Newly created global laboratory model

- Second meeting February 27, 2002

  Detailed discussions on each possible model were continued regarding their advantages, shortages, feasibility, consequences and so on. A possible scheme of the organization and its operation for each model was also discussed. After the meeting, exchange of views was continued via E-mail and also in extra small meetings with a member who could not attend the committee meeting. In the mean-time, the writing committee began to summarize the discussions in a form to answer the given mandate.

- Third meeting April 22, 23, 2002

1. Discussions on the models continued and a consensus was reached on the choice of a preferred model in view of the necessary features for the organization.
2. Discussions covered how to proceed toward the desired solution and on what to recommend as the first step. The discussion included detailed possible actions to be taken along the chosen scenario.
3. Discussions on the issues of the mandate in the category b), i.e. those which do not depend on the form of the organization.
4. Discussions on the content of the report
5. Future procedure for completion of the report

Following these discussions, the first draft of the report was completed by the writing sub-committee and was circulated to all the members in late June. Given comments and propositions were studied by the writing sub-committee to produce a revised draft, which was completed in August. Further iterations have been made to finalize the report.