Executive Summary

International Technology Recommendation Panel

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1. Introduction

Particle physics stands at the threshold of discovery. The standard model gives a precise and quantitative description of the interactions of quarks and leptons. Its predictions have been confirmed by hundreds of experimental measurements. Nevertheless, experiments at accelerators and observations of the cosmos point to phenomena that cannot be explained by the standard model. Dark matter, dark energy and neutrino masses all require new physics beyond present understanding. Exploring this new frontier will be the task of twenty-first century particle physics.

The essential first step is to find the Higgs boson, or whatever mechanism takes its place. The Higgs is a revolutionary new form of matter whose interactions give mass to the elementary particles. If it exists, the Higgs should be discovered at the CERN LHC, but measuring its properties with precision will require a TeV-scale electron-positron linear collider. Beyond the Higgs, strong arguments suggest that the TeV scale will be fertile ground for discovery. The LHC will open this new territory, and a TeV-scale linear collider will be necessary to explore it in detail. Higher precision leads to greater understanding and discovery. For these reasons, the global particle physics community has endorsed such a linear collider as the next major step in the field. The case for its construction is firm.

During the past decade, dedicated and successful work by several research groups has demonstrated that a linear collider can be built and reliably operated. There are two competing designs. One, developed by the TESLA collaboration, accelerates beams in 1.3 GHz (L-band) superconducting cavities. The other, a result of joint research by the NLC and GLC collaborations, accelerates beams using 11.4 GHz (X-band) room temperature copper structures. Both R&D programs have verified the proofs of principle for the accelerating structures and the systems that drive them. The critical R&D steps were reviewed in the Technical Review Committee (TRC) charged by the International Committee for Future Accelerators (ICFA) to assess the technical readiness of these designs. The essential R&D milestones identified by the TRC in its 2003 report have now been met.

In 2004, ICFA formed the International Technology Recommendation Panel (ITRP) to evaluate the two technologies and to recommend a single choice on which to base the linear collider. Our panel met six times from January to August 2004 to hear presentations by the proponents of the two projects, gather input from the wider community, evaluate the information and prepare our recommendation. We requested responses from the proponents to an extensive set of questions. We based our decision on a set of criteria that addressed scientific, technical, cost, schedule, operability issues for each technology, as well as their wider impacts on the field and beyond.

2. Recommendation and rationale

The ITRP charge specified a set of design goals for the linear collider. We found that both technologies can achieve the goals presented in the charge. Both have been pursued by dedicated and talented collaborations of physicists and engineers from around the world. Each collaboration has made important contributions that will prove essential to the successful realization of the linear collider.

The details of our assessment are presented in the body of this report. On the basis of that assessment, we recommend that the linear collider be based on superconducting rf technology. This recommendation is made with the understanding that we are recommending a technology, not a design. We expect the final design to be developed by a team drawn from the combined warm and cold linear collider communities, taking full advantage of the experience and expertise of both.

Our evaluation process focused on the major acceleration and beam transfer elements of each design. We also examined other critical components, including the damping rings and the positron source. We found that both technologies can achieve the goals presented in the charge. Each had considerable strengths.

The warm technology allows a greater energy reach for a fixed length, and the damping rings and positron source are simpler. The panel acknowledged that these are strong arguments in favor of the warm technology. One member (Sugawara) felt that they were decisive.

The superconducting technology has features, some of which follow from the low rf frequency, that the Panel considered attractive and that will facilitate the future design:

- The large cavity aperture and long bunch interval simplify operations, reduce the sensitivity to ground motion, permit inter-bunch feedback, and may enable increased beam current.

- The main linac and rf systems, the single largest technical cost elements, are of comparatively lower risk.

- The construction of the superconducting XFEL free electron laser will provide prototypes and test many aspects of the linac.

- The industrialization of most major components of the linac is underway.

- The use of superconducting cavities significantly reduces power consumption.

Both technologies have wider impact beyond particle physics. The superconducting rf technology has applications in other fields of accelerator-based research, while the X-band rf technology has applications in medicine and other areas.

3. The next steps

The choice of the technology should enable the project to move forward rapidly. This will require the engagement of both cold and warm proponents, augmented by new teams from laboratories and universities in all regions. The experience gained from the Stanford Linear Collider and Final Focus Test Beam at SLAC, the Accelerator Test Facility at KEK, and the TESLA Test Facility at DESY will be crucial in the design, construction and operation of the machine. The range of systems from sources to beam delivery is so extensive that an optimized design can only emerge by pooling the expertise of all participants.

The machine will be designed to begin operation at 500 GeV, with a capability for an upgrade to about 1 TeV, as the physics requires. This capability is an essential feature of the design. Therefore we urge that part of the global R&D and design effort be focused on increasing the ultimate collider energy to the maximum extent feasible.

We endorse the effort now underway to establish an international model for the design, engineering, industrialization and construction of the linear collider. Formulating that model in consultation with governments is an immediate priority. Strong central management will be critical from the beginning.

A TeV scale electron-positron linear collider is an essential part of a grand adventure that will provide new insights into the structure of space, time, matter and energy. We believe that the technology for achieving this goal is now in hand, and that the prospects for its success are extraordinarily bright.