The NLC Design Group

C. Adolphsen, R. Aiello, R. Alley, R. Assmann, K.L. Bane, T. Barklow, V. Bharadwaj, J. Bogart, G.B. Bowden, M. Breidenbach, K.L. Brown, D.L. Burke, Y. Cai, G. Caryotakis, R.L. Cassel, P. Chen, S.L. Clark, J.E. Clendenin, C. Corvin, F.-J. Decker, A. Donaldson, R.A. Early, K.R. Eppley, S. Ecklund, J. Eichner, P. Emma, L. Eriksson, Z.D. Farkas, A.S. Fisher, C. Foundoulis, W.R. Fowkes, J. Frisch, R.W. Fuller, L. Genova, S. Gold, G. Gross, S. Hanna, S. Hartman, S.A. Heifets, L. Hendrickson, R.H. Helm, H.A. Hoag, J. Hodgson, J. Humphrey, R. Humphrey, J. Irwin, R.K. Jobe, R.M. Jones, L.P. Keller, K. Ko, R.F. Koontz, E. Kraft, P. Krejcik, A. Kulikov, T.L. Lavine, Z. Li, W. Linebarger, G.A. Loew, R.J. Loewen, T.W. Markiewicz, T. Maruyama, T.S. Mattison, B. McKee, R. Messner, R.H. Miller, M.G. Minty, W. Moshammer, M. Munro, C.D. Nantista, E.M. Nelson, W.R. Nelson, C.K. Ng, Y. Nosochkov, D. Palmer, R.B. Palmer, J.M. Paterson, C. Pearson, R.M. Phillips, N. Phinney, R. Pope, T.O. Raubenheimer,[1] J. Rifkin, S.H. Rokni, M.C. Ross, R.E. Ruland, R.D. Ruth, A. Saab, H. Schwarz, B. Scott, J.C. Sheppard, H. Shoaee, S. Smith, W.L. Spence, C.M. Spencer, J.E. Spencer, D. Sprehn, G. Stupakov, H. Tang, S.G. Tantawi, P. Tenenbaum, F. Tian, K.A. Thompson, J. Turner, T. Usher, A.E. Vlieks, D.R. Walz, J.W. Wang, A.W. Weidemann, D.H. Whittum, P.B. Wilson, Z. Wilson, M. Woodley, M. Woods, Y.T. Yan, A.D. Yeremian, F. Zimmermann; *Stanford Linear Accelerator Center, Stanford, California, USA*

A. Jackson, W.A. Barletta, J.M. Byrd, S. Chattopadhyay, J.N. Corlett, W.M. Fawley, M. Furman, E. Henestroza, R.A. Jacobsen, K.-J. Kim, H. Li, H. Murayama, L. Reginato, R.A. Rimmer, D. Robin, M. Ronan, A.M. Sessler, D. Vanecek, J.S. Wurtele, M. Xie, S.S. Yu, A.A. Zholents; *Lawrence Berkeley National Laboratory, Berkeley, California, USA*

L. Bertolini, K. Van Bibber, D. Clem, F. Deadrick, T. Houck, M. Perry, G.A. Westenskow; *Lawrence Livermore National Laboratory, Livermore, California, USA*

M. Akemoto, T. Higo, K. Higashi, K. Kubo, K. Oide, K. Yokoya; *KEK National Laboratory, Tsukuba, Japan*

L. Rinolfi; *CERN, Geneva, Switzerland*

J.A. Holt; *Fermilab National Laboratory, Batavia, Illinois, USA*

V. Telnov; *Budker Institute for Nuclear Physics, Novosibirsk, Russia*

T. Takahashi, T. Ohgaki; *Hiroshima University, Hiroshima, Japan*

J. Rosenzweig; *University of California, Los Angeles, Los Angeles, California, USA*

S. Lidia; *University of California, Davis, Davis, California, USA*

N.M. Kroll; *University of California, San Diego, San Diego, California, USA*

A.J. Dragt, R.L. Gluckstern; *University of Maryland, College Park, Maryland, USA*

S.R. Hertzbach; *University of Massachusetts, Amherst, Massachusetts, USA*

G. Giordano; *University of Milano, Milan, Italy*

R.E. Frey; *University of Oregon, Eugene, Oregon, USA*

D.D. Meyerhofer; *University of Rochester, Rochester, New York, USA*

[1] Editor-in-chief.

Acknowledgments

This design for the Next Linear Collider (NLC) relies heavily on the first linear collider—the Stanford Linear Collider (SLC)—and on all the people who proposed, designed, and commissioned this pioneering accelerator. Without their work, none of this would have been possible (or necessary). In addition, the design owes much to the extensive international research effort that is investigating the different technological paths to a future linear collider. Finally, the NLC Design Group is a list of people, authors and non-authors, who have contributed significantly to this design; our apology in advance to anyone whose name may have inadvertantly been omitted.

In the process of completing this "Zeroth-Order Design" for the NLC, we have held two internal reviews and, more recently, an international external review. All of these have been very important to the design and we thank all of those who assisted. In particular, we thank the members of the external review panel which consisted of: Gerry Dugan, Helen Edwards, Hans Frischholz, David Gurd, Tom Himel, Steve Holmes, Norbert Holtkamp, John Ives, Robert Jameson, Katsunobu Oide, Satoshi Ozaki, John Rees, Nobu Toge. A number of useful comments were made, some of which already have been incorporated into the design. Most members of the internal review committees are listed in the contributors list; additional useful suggestions were given by H. DeStaebler, J.T. Seeman, R.H. Siemann, U. Wienands, and M. Zisman, along with many other members of the LBL, LLNL, and SLAC communities.

Finally, we would like to thank Angie Seymour, Marge Bangali, and Mary Litynski for administrative support, Terry Anderson, Sylvia MacBride, and Jim Wahl for creating the illustrations, and Jamie Walker and Laurie Gennari for producing this document.

Contents

Preface

This "Zeroth-Order Design Report" (ZDR) for the Next Linear Collider (NLC) is being created at a time of both great opportunity and uncertainty in the future directions that will be taken by the world-wide community of high-energy physics. There is exciting news that the Large Hadron Collider project has been approved for construction at CERN, and the planned involvement by physicists and engineers from countries around the globe will make this the first accelerator to be designed and built by a truly world-wide collaboration. By contrast, the cancellation of the SSC has demonstrated the necessity of international collaboration on such large scientific projects. The community of scientists and engineers at work on the accelerator physics and technologies of high-energy electron-positron colliders has recognized this need, and has made concerted effort to coordinate research activities to optimize our combined understanding and knowledge. This ZDR is one further step in this process.

The first electron-positron linear collider, the Stanford Linear Collider (SLC), began operation in 1989 with the dual purpose to explore the particle physics of the Z^0 boson and to develop the accelerator physics needed for a future TeV-scale linear collider. The SLC program has proven to be quite successful on both counts. Experiences gained and lessons learned from this prototype collider are a firm foundation for the design and implementation of a next generation machine. Developments at laboratories around the world have led to several choices of technologies to efficiently accelerate beams of electrons and positrons to high energy, and major test facilities presently nearing completion will soon allow evaluation of complete systems of these acceleration techniques. Additional test facilities already, or soon will, provide demonstrations and experience with techniques to create and control the delicate beams required to achieve the high luminosities needed for particle physics at the TeV-scale.

This NLC ZDR has been completed in the above context as a feasibility study for a TeV-scale linear collider that incorporates a room-temperature accelerator powered by rf microwaves at 11.424 GHz—similar to that presently used in the SLC, but at four times the rf frequency. The purpose of this study is to examine the complete systems of such a collider, to understand how the parts fit together, and to make certain that every required piece has been included. The "design" presented here is not fully engineered in any sense, but to be assured that the NLC can be built, attention has been given to a number of critical components and issues that present special challenges. More engineering and development of a number of mechanical and electrical systems remain to be done, but the conclusion of this study is that indeed the NLC is technically feasible and can be expected to reach the performance levels required to perform research at the TeV energy scale.

It is important to recognize that the contents of this ZDR include the work of many people not acknowledged as authors in the subsections of the report. This ZDR is the result of many years of discussion and investigation with scientists and engineers from around the world. References have been given in the text, but it is not always possible to accurately identify the true source of many of the notions and ideas included in a work of this type. The authors of this report apologize in advance for omissions. Effort has been made to use technical definitions in this ZDR that conform as widely as possible to those used in the recently completed International Linear Collider Technical Review Committee Report (The TRC Report, edited by G. Loew, SLAC Report–471, 1996). The ideas and parameters that appear in this ZDR have evolved from those given in the TRC report. Even so, the TRC report is a valuable companion to this document.