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Physics and Technology of the Next Linear Collider:

A Report Submitted to Snowmass '96 by the NLC Zeroth-Order Design Group and the NLC Physics Working Group

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PREFACE

We present the prospects for the next generation of high-energy physics experiments with electron-positron colliding beams. This report summarizes the current status of the design and technological basis of a linear collider of center-of-mass energy 0.5–1.5 TeV, and the opportunities for high-energy physics experiments that this machine is expected to open.

Over the past two decades, particle physics experiments have made an increasingly precise confirmation of the "Standard Model" of strong, weak, and electromagnetic interactions. High-energy physicists feel confident that the basic structure of these once-mysterious interactions of elementary particles is now well understood. But the verification of this model has brought with it the realization that there is a missing piece to the story: although the structure of the weak interactions is based on a symmetry principle, we observe that symmetry to be broken, by an agent that we do not yet know. This agent, whatever its source, must provide new physical phenomena at the TeV energy scale.

The Large Hadron Collider (LHC) in Europe offers an entry into this energy regime with significant opportunity for discovery of new phenomena. An electron-positron collider at this next step in energy, the Next Linear Collider (NLC), will provide a complementary program of experiments with unique opportunities for both discovery and precision measurement. To understand the nature of the new phenomena at the TeV scale, to see how they fit together with the known particles and interactions into a grander picture, both of these facilities will be required.

In particular, electron-positron colliders offer specific features that are essential to understand the nature of these new interactions whatever their source. They allow precise and detailed studies of the two known particles that couple most strongly to these interactions, the W boson and the top quark. They provide a clean environment for the discovery of new particles whatever their nature, and they provide special tools, such as the use of electron beam polarization, to dissect the couplings of those particles.

All of this would be merely theoretical if the next-generation linear collider could not be realized. But, in the past few years, the technology of the linear collider has come of age. The experience gained from the operation of the Stanford Linear Collider (SLC) has provided a firm foundation to the design choices for the NLC. The fundamental new technologies needed to construct the NLC have been demonstrated experimentally. Microwave power sources have exceeded requirements for the initial stage of the NLC, and critical tests assure us that this technology can be expected to drive beams to a center-of-mass energies of a TeV or more. Essential demonstrations of prototype collider subsystems have either taken place or are now underway: the Final Focus Test Beam has already operated successfully; a linear accelerator and a damping ring will be operated within the next year. A detailed feasibility study, the "Zeroth-Order Design Report" (ZDR), has shown that these components can be integrated into a complete machine design.

The Next Linear Collider can be constructed, and it will play an essential role in our understanding of physics at the TeV energy scale.

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