2.13 Conclusions

The Standard Model of strong and electroweak interactions represents a tremendous scientific achievement. It provides an elegant and well tested description of fundamental forces based on underlying local symmetry concepts. However, despite those successes, some basic questions remain unanswered. Addressing those issues should guide us to a deeper understanding and better appreciation of Nature's laws.

What is the origin of electroweak symmetry breaking and mass generation? That outstanding problem drives high energy physics and establishes its experimental goals. Fortunately, resolution of that puzzle appears to be within reach of the next generation of hadron and lepton colliders, the LHC and the NLC.

In this report, we have described some of the physics goals and capabilities of the NLC, emphasizing both its unique features and complementarity to the LHC program planned at CERN. The envisioned project would start with an initial variable center-of-mass energy up to about 500 GeV and be upgradable to 1–1.5 TeV. It would feature a highly polarized e^- beam as well as e^-e^-, γe^- and $\gamma\gamma$ collider options.

The first phase of the NLC guarantees extensive physics capabilities and interesting discovery potential. Sitting at and above the $t\bar{t}$ threshold will allow unprecedented precision measurements of the top quark's mass, partial decay widths, gauge and Higgs boson couplings etc. Its very large mass may be a signal of the top quark's special role in elementary particle physics and electroweak symmetry breaking. We must, therefore, explore its properties and search for additional anomalous features. In that endeavor, the LHC will be a top quark factory, capable of producing and studying samples of order 10^7 tops in a number of characteristic signatures. The NLC will complement such studies as a precision instrument which is sensitive to the broad range of top couplings to strong and weak gauge bosons. Similarly, studies of gauge boson pair production at the NLC will provide high precision measurements of triple-gauge boson couplings at the level of 1–0.1% (with increasing center-of-mass energy). At that level of sensitivity anomalous properties could become unveiled, particularly if there is new strong dynamics at ~ 1 TeV.

If a fundamental Higgs scalar exists and has mass below 350 GeV, it will be found and studied in the first phase of the NLC via $e^+e^- \to ZH$. That mass reach is extremely broad and encompasses a most important domain. If the Standard Model is perturbative up to grand-unification energies, then $m_H \lesssim 200$ GeV. If supersymmetry is manifested at the electroweak scale, then the lightest scalar satisfies $m_h < 150$ GeV. The first stage of the NLC will be definitive in confirming or negating those expectations. A higher mass Higgs (> 350 GeV) would be easily accessed at the LHC or higher energy phases of NLC. Additional Higgs scalars of SUSY scenarios, or pseudo-Goldstone bosons of dynamical symmetry breaking schemes, would be unveiled in pair-production as their thresholds are passed at the NLC. The clean environment of that facility would allow detailed studies of their decay patterns. A compelling feature of e^+e^- colliders is the ability to not only produce new particles, but to thoroughly explore their properties.

If supersymmetry manifests itself near the electroweak scale, a plethora of new particles, the supersymmetric partners of quark, leptons, and gauge bosons, awaits discovery. Unfolding that entire spectrum and its properties will require the full capabilities of the LHC and NLC. The first direct evidence for production of gluinos and squarks should be found at LHC, if not already at the Tevatron. On the other hand, the study of color-singlet superpartners is best carried out at e^+e^- colliders. Since these particles are typically lighter, they determine the decay patterns of the particles produced in strong interactions. Thus, the NLC will be essential for unraveling the entire spectrum and precisely measuring the new particle properties. The study of superpartners will be greatly facilitated by use of the high e^- polarization both for suppressing backgrounds and enhancing signals. High precision determinations of the SUSY parameters will provide important insight and constraints on the mechanism of SUSY breaking, as well as a potential new window to the physics of grand unification and superstrings.

If new strong dynamics is responsible for electroweak symmetry breaking, it may be difficult to uncover and fully explore. In such a scenario, the NLC will be an extremely valuable instrument. It will probe the new dynamics via $W^+W^- \to W^+W^-$ and $W^+W^- \to t\bar{t}$ scattering, and through anomalous gauge boson couplings and other probes in $e^+e^- \to W^+W^-$. Such studies will become ever more revealing as the higher energy upgrades are attained. In addition, new strong dynamics is likely to imply a wealth of spectroscopy at very high energies. The NLC, particularly its highest energy phase, should be a very important facility for discovering and studying such states.

The new energy domain opened up by the NLC will also allow systematic searches for new particles such as Z' bosons, heavy fermions, leptoquarks, etc. If such particles are found, the e^- polarization will be extremely useful for deciphering their properties.

The physics capabilities of the NLC can be greatly expanded by the e^-e^-, γe^-, and $\gamma\gamma$ collider options possible at such an accelerator. Those collision modes will complement e^+e^- studies and could prove particularly useful to provide new observables of supersymmetric particles, to study the Higgs boson as an s-channel resonance, and to explore W^-W^- scattering.

During the twentieth century, elementary particle physics emerged as a scientific discipline. Since its inception, progress and advancement have followed our ability to probe short distances via high energy collisions. By pushing to even higher energies, we should be able to continue the advancement. In this report, we have reviewed the questions that are now at the frontier of particle physics, and we have shown that the NLC has a central role is answering every one. We thus view the NLC as a forefront facility for particle physics, an essential tool for probing the hidden symmetries of Nature, a well tuned instrument for the start of our next millennium.