International Linear Collider: A Global Project

Submitted by the Americas Linear Collider Committee

Abstract
A worldwide community of physicists and laboratories intends to realize a physics program of energy-frontier, electron-positron collisions with the International Linear Collider (ILC). The project would be hosted in Japan with participation from around the globe. Snowmass participants are strongly encouraged to participate in the ILC studies.

Introduction
Over the course of the past fifty years, the use of colliding beams has emerged as the technique of choice with which to access the highest possible energies achievable in the laboratory. Lepton (with electron-positron), and hadron (proton and antiproton) beams have provided complementary capabilities. Together these approaches have provided much of the data which underpins the current Standard Model of particle physics. Both linear and circular electron-positron colliders are possible. While the circular colliders have been the usual choice thus far, linear colliders become more attractive for higher energies for electron-positron collisions. The physics motivation sharpened with the discovery of the 125 GeV Higgs boson in 2012. A linear collider allows us to measure the complete profile of the Higgs boson with high precision and offers a path to higher energies.

Physics Program
The 2014 P5 report and the recent European Strategy for Particle Physics, broadly emphasized the importance of exploring the properties of the Higgs boson as a window on new physics. Therefore, the ILC physics program will begin with a central focus on high-precision and model-independent measurements of the Higgs boson couplings. This method of searching for new physics is orthogonal to and complements the direct search HL-LHC physics program. The ILC can achieve percent level or better precision on several decay channels. It reaches sub-percent level sensitivity to invisible Higgs decays, and provides excellent sensitivity to the LHC-challenging decay channel of Higgs to charm. The initial stage of the ILC at 250 GeV will also search for direct new physics in exotic Higgs decays and in pair-production of weakly interacting particles. Polarized electron and positron beams add unique opportunities to the physics reach. The ILC can be upgraded to higher energies, enabling precision studies of the top quark, measurement of the top Yukawa coupling, and the Higgs self-coupling.

Accelerator Technology
In 2004, an international panel recommended that a future linear collider use superconducting RF (SRF) acceleration. Warm RF structures are still under development, but for the energies up to 1 TeV, the SRF option is generally favored. In 2005, ICFA created the Global Design Effort, which completed and published a comprehensive Technical Design Report for the International Linear Collider in 2013. Subsequently the international efforts, with an emphasis on siting the project in Japan, have been guided by ICFA through its Linear Collider Board (LCB) subcommittee and the Linear Collider Collaboration (LCC) engaging a global community of physicists working together on all aspects (physics, detectors and accelerator).

Advances in SRF cavities were made at LEP and CESR, then at larger scale with CEBAF and SNS. During the past decade, the technique has seen ubiquitous use across the world in many accelerators. The completion of the European XFEL facility at DESY provides an important step forward at the scale of 10% of the ILC. In the U. S., the inter-laboratory collaboration to construct the LCLS II has broadened the expertise in this technology.

Despite its successes, the SRF technology is still relatively young. We continue to make progress in understanding the surface physics of SRF cavities and improving gradient and quality factor performance. Very significant increases in the maximum sustainable accelerating gradient have been demonstrated at Fermilab and confirmed in laboratories around the world. The breadth of this collaborative work will provide a strong base for the ILC fabrication and construction.

Detectors

Detector designs have been developed by the global ILC community. Two concepts emerged and were thoroughly reviewed and validated. The Silicon Detector (SiD), features an all-silicon tracker, and the International Large Detector (ILD), uses a large TPC tracker. The designs share an emphasis on vertex detectors with a small inner radius, low-mass tracking with gaseous rather than liquid cooling, which is enabled by the ILC beam structure, and highly granular calorimeters. The designs maximally exploit the benefits of the e+e- linear collider environment achieving comprehensive reconstruction of the events. Trigger-less readout of the events will support searches for new signatures in addition to unbiased precision measurements of known phenomena. The absence of strong interaction background processes will greatly simplify the analysis and interpretation of data.

Extensive detector R&D studies over the past decade, initially supported by a vigorous R&D program in the U.S. as well as globally, were carried out by both ILC and CLIC detector collaborations. This work demonstrated the feasibility of several technologies that have found their way into other HEP experiments, e.g. DEPFET at Belle II and HGCal at CMS.

Going forward, the two concepts SiD and ILD provide an ideal basis for critical R&D, and a starting point for further evolution of the designs. The broader goal is to strengthen, extend, refine, and engineer the detector designs, and to explore alternative approaches for inclusion in the eventual proposals, and the discussion of the experimental program, in time for construction.

Recent Project Planning

There is a strong interest in Japan to host this international effort and a detailed review has been completed. Now the Japanese government is preparing for a decision on the next phase of international negotiations. ICFA therefore decided to make a transition from the LCC-LCB structure by mid 2020. It is forming a team hosted by KEK to help create the ILC Pre-Laboratory. This transition team includes representatives from all regions, and Working Group leaders for both the accelerator and the physics and detectors; it is expected to have a lifetime of ~12-18 months. The potential timeline of the ILC project envisages a Pre-Laboratory phase of about 4 years. The ILC construction proper would take about a decade.

The ILC and Snowmass

The International Linear Collider is a mature project, well matched to the contemporary needs of particle physics. Extensive discussion of the ILC project and a major reinvigoration of the participation of the U.S particle physics community in concert with its global partners is appropriate. It is time for an open discussion of the ways in which the U.S. Community and its supporting laboratories can envisage leadership roles within the ILC project. A document with a compilation of physics and detector issues designed to encourage and guide immediate studies, is in preparation.

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Linear Collider Collaboration, www.linearcollider.org. ; https://ilchome.web.cern.ch/

(*) give the most recent descriptions of the accelerator and projections of the ILC capabilities