

**1. NAME OF INITIATIVE:** International Linear Collider (ILC)  
*List of major collaborating institutions (including non-US partners).*

1a. International Linear Collider Accelerator R&D

Fermilab is the only US laboratory that collaborates on both the X-Band and SCRF accelerator R&D. As such we are positioned to provide leadership within the accelerator R&D program independent of the technology recommendation expected later this summer.

List of major collaborating institutions:  
SLAC, DESY, ANL, JLab, Cornell, SNS, LANL, BNL, LBNL, University of Chicago, Northwestern University, Northern Illinois University, Illinois Institute of Technology and University of Illinois at Urbana-Champaign.

1b. International Linear Collider Detector Design and R&D

The Linear Collider detector design group has started an initiative to create a conceptual detector design report by the fall of 2005. Fermilab, together with SLAC, intends to play a major role in this design and continue R&D on several of the sub detectors for such a facility.

List of major collaborating institutions:  
Participating & collaborating institutions: many of the Fermilab user universities (too many to list) as well as Argonne and SLAC in the US. We expect this to be an international effort with participation from institutions from all over the globe.

1c. Linear Collider Global Design Initiative/Central Team

Fermilab has submitted to International Linear Collider Steering Committee (ILCSC) a bid to host the Central Team of the GDI (GDI/CT) at the Fermi National Accelerator Laboratory. If selected, the international design team will be located at Fermilab, and will work closely with the worldwide ILC collaborations produce an engineering design for a linear collider. It is expected that this team will include several Fermilab staff.

1d. ILC Construction and Operations

Fermilab is committed to significant participation in the construction and operations of an International Linear Collider independent of the site or the base technology. Fermilab has also publicly stated its desire to serve as host laboratory to the ILC. Among the attributes we feel make Fermilab/Northern Illinois extremely attractive as the host lab/region are: scientific and engineering expertise in forefront accelerator technologies, significant experience in the construction and operations of large accelerator projects, the leadership mantle of U.S. high energy physics/a strong scientific base including two national laboratories and five major research universities, geology ideally suited to a linear collider, and transportation and utilities infrastructure that could support ILC construction and operations.

List of major collaborating institutions:  
The international linear collider collaboration.

## **2. SCIENTIFIC JUSTIFICATION:**

*Physics goals. How does it fit into the global physics goals for the entire field.*

The scientific case for the ILC has been made in several publications worldwide. The document “Understanding Matter, Energy, Space and Time: the Case for the Linear Collider” provides a comprehensive, detailed scientific justification for a Linear Collider operating concurrently with the LHC. This document can be found at [http://sbhep1.physics.sunysb.edu/~grannis/lc\\_consensus.html](http://sbhep1.physics.sunysb.edu/~grannis/lc_consensus.html). Similar documents have been produced in Europe and Asia.

## **3. VALIDATIONS FOR SCIENTIFIC JUSTIFICATION:**

*Examples of recommendations and supporting statements from the committees, panels, and the community at large.*

Validation of the scientific justification has come in the form of statements from the major high energy physics advisory committees around the world (HEPAP in the U.S. and ACFA and ECFA in Asia and Europe) advocating an internationally constructed and operated linear collider as the next major facility following LHC. The International Committee on Future Accelerators (ICFA) has issued a similar endorsement.

The Department of Energy Office of Science reports “Facilities for the Future of Science: A Twenty-Year Outlook” and “Quantum Universe” have endorsed the Linear Collider as the highest priority major project for the next decade.

The Fermilab Long Range Planning Committee issued its report and recommendations to Fermilab Director Mike Witherell in the spring of 2004. The report of the committee “The Coming Revolution in Particle Physics” and Mike Witherell vision document “Discovery at Fermilab: The Next Twenty Years” can both be found at

[http://www.fnal.gov/directorate/Longrange/Long\\_range\\_planning.html](http://www.fnal.gov/directorate/Longrange/Long_range_planning.html)

These two documents establish construction of the ILC, with Fermilab as host laboratory, as the preferred option for the future, and outline the steps required to fulfill this vision.

## **4. DESIRED SCHEDULE:**

*List major milestones (month & year) such as design complete, construction start, construction complete, etc.*

No firmly established schedule for the ILC exists as this is not an approved project. The following high level schedule is consistent with current discussions within the scientific community and among the funding agencies. However, further evolution is likely under the influence of both technical and political pressures.

2004: International technology recommendation. Identify GDI Central Team Site and Organization. Consolidation of Fermilab effort in line with technology recommendation.

2005: Establish GDI organization and responsibilities, and initiate CDR.

2005-2006: Complete the CDR, including site requirements, and initial cost and schedule plan. Establish goals for a complete engineering systems test.

2006-7: Initiate detailed engineering designs under the leadership of GDI/CT. Establish engineering systems test facilities.

2008-9: Complete detailed EDR with the cost and schedule plan. Establish roles & responsibilities of regions, and begin the process for site proposals.

2009-10: Site selection and approval of international role & responsibilities by the governments. Initiate site specific design.

2009-11: Complete site specific design

2010-2012: Start of ILC construction

2015-2018: ILC construction complete

Fermilab Linear Collider Accelerator R&D efforts need to be in concert with the ILC schedule. We will work with the Central Team of the Global Design Initiative for the ILC to refine these schedules.

##### **5. ROUGH ESTIMATE OF COST RANGES:**

*Whatever the best information available (eg. \$M +/-30~50%, \$150~250M, etc.). Total cost range including non-DOE funding (if any other funding sources are assumed and if known, state from where and how much. Also indicate remaining R&D cost to go.*

The present ILC budget of Fermilab is about \$4M, including both the X-Band (\$3M and SCRF \$1M). There is an additional \$1M for other SCRF work not related to ILC.

Fermilab supports about 40 FTE with this budget. We expect that these resources will consolidate after the technology recommendation. But total ILC resources need to grow significantly world-wide to realize its schedule.

Fermilab has proposed an Engineering Test Facility for the Linear Collider. We believe that a ~1% system test is required to promote industrialization and to insure reliability of the cost, schedule, and performance goals of the ILC. In addition Fermilab has submitted a bid to host the GDI/CT. The FLRPC report estimates that Fermilab resources invested in the Linear Collider R&D need to grow by roughly a factor of five at the time of ETF construction (~\$20M/year) and by an additional factor of five by the start of LC construction near Fermilab (~\$100M/year). This investment could potentially grow by an additional 50% during the construction phase, depending on the international financial model in place. The significant majority of this funding needs to be directed toward the accelerator. In an ideal situation the ILC Fermilab budget should be \$10M (FY05), \$20M (FY06) and \$40M (FY07).

A successful bid to host the GDI Central Team would incur annual expenses in the \$500K range. If linear collider construction were to proceed the total cost would be in the \$5-10B range world-wide, with the U.S. share roughly half.

## 6. DESIRED NEAR TERM R&D:

*Major activities needed to be completed before start construction.*

**Accelerator Physics:** Fermilab is collaborating on three major topics for the Linear Collider accelerator physics.

- Production of small emittance electron beams at Fermilab NICADD Photo Injector Laboratory (FNPL). A series of upgrades are planned involving production of high brightness beams, flat beam investigations, and development of polarized rf guns.
- Damping Ring: Fermilab ILC Damping Ring efforts include design of a new TESLA damping ring and study of the NLC pre-damping ring. The goal is to reduction of the damping ring circumference in the case of TESLA. We have developed a preliminary design of 6 km circular damping ring for TESLA in collaboration with Cornell, LBNL, and ANL. We are in process of developing detailed design of this damping ring, including design of a fast kicker, wiggler, dynamic aperture, magnet quality and calculations of instabilities, electron cloud and fast ion instabilities in this design. These calculations will help Fermilab develop expertise in damping ring accelerator physics. Once these tools are in place we will work with ILC collaborators in developing final design of a damping ring of the selected technology.
- Low Emittance Transport: The transport of a low emittance beam from the exit of the damping ring to IP will be one of the challenges for achieving the design luminosity of the linear collider. Fermilab, in collaboration, with SLAC is developing tools to study the preservation of emittance in the main linac including effects of wake-field, ground motion, and vibrations.

**Accelerator Technology:** Fermilab will continue to work on both the X-Band and SCRF technology development through the technology selection. We have developed plans for the continuation of R&D in either direction following the technology selection (expected 4<sup>th</sup> quarter of FY04).

- X-Band Technology: Fermilab will continue to produce X-band accelerating structures and take the lead in industrialization of the process. As part of this program we will develop capability of X-band power at Fermilab. We will finish the R&D on Girder and start construction of a prototype. We would hope to host the ETF for a warm LC in this case. Fermilab has been and will remain in the lead on support girder design. We will continue to work in collaboration with SLAC, Northwestern University, and Northern Illinois University gathering data on ground motion in several tunnels in Northern Illinois.
- SCRF Technology: The Fermilab NICADD Photoinjector Laboratory is the test-bed of superconducting technologies related to linear colliders. The laboratory includes a laser driven source with all the characteristics required of the electron source for a cold linear collider. Essential tests related to flat beam and polarized

beam production will continue. The facility is in the process of being upgraded through the addition of 3.9 GHz (3<sup>rd</sup> harmonic) accelerating and deflecting cavities.

In parallel Fermilab has been developing expertise in SCRF technologies with a goal towards development of a U.S. capability to fabricate in quantity structures capable of 35 MV/m. Such activities are being undertaken with a number of U.S. laboratories (ANL, Cornell, JLab, LANL, LBNL, ORNL, BNL, MIT) under the mantle of the Superconducting Module Test Facility (SMTF) collaboration. Fermilab has expressed the desire to assume the lead in the U.S. effort following a cold decision. Such efforts would be closely coordinated with international collaborators including members of the TESLA collaboration and others.

Some additional activities for SCRF technology development have been described in the initiative documents for the Proton Driver and SMTF. The SCRF Linear Collider will greatly benefit from these R&D.

**Engineering Test Facility:** In FY04 the Fermilab proposed that an Engineering Test Facility for the Linear Collider will be needed to establish with confidence that an LC, as designed, can be constructed for the cost specified, on the schedule specified, and meeting the established performance specification. We envision that such a facility will address engineering, accelerator physics, management, and organizational issues. The scope of such a facility needs to be defined. Fermilab is discussing these ideas with the Linear Collider community but the final design and goals will be developed by the Central Team of the Global Design Initiative. Fermilab would expect to bid to host such a facility, but would expect to contribute no matter where constructed. In the event of a cold decision the ETF could have considerable overlap with SMTF and/or Proton Driver test facility. In the event of a warm decision we would anticipate a stand-alone facility of several GeV.

**Civil and Geology:** Fermilab, in collaboration with SLAC and Northern Illinois University, has taken a leadership role in civil and geological studies for both Illinois and California, and for both warm and cold technologies. We will be working on refining these studies in next two fiscal years. In addition Fermilab anticipates developing an ILC site plan for construction near Fermilab including, identification of a preferred site in northern.

**Outreach:** The International Linear Collider is among the largest scientific projects ever contemplated. It will require support from a broader group of people. Fermilab has formed an outreach committee to develop and implement an ILC outreach program for an ILC funding and construction in Illinois. The outreach activity will be directed to several different constituencies, including

- The Federal government, including both the Congress and the Executive Branch
- The Illinois State Government
- The High Energy Physics Community
- The scientific community beyond high energy physics
- Local universities, businesses and laboratories

- The communities nearby the Linear Collider site and Fermilab
- The broad public, especially young people.

**Detector Design and R&D:** The Linear Collider detector design group has started an initiative to create a conceptual detector design report by the fall of 2005. Fermilab, together with SLAC, intends to play a major role in this design and continue R&D on several of the sub detectors for such a facility. Participating and collaborating institutions include many of the Fermilab user universities as well as Argonne and SLAC in the US. We expect this to be an international effort with participation from institutions from all over the globe.

As part of a bid to host the ILC and/or to participate in the physics program of such a machine, no matter where it is built, we need to use and strengthen Fermilab's expertise in the area of detector design, development, ASIC chip design & development, simulation, software and detector R&D for a future ILC detector. Especially in the area of silicon tracking we want to pursue new detection techniques (monolithic active pixels) and new readout electronics (ASICs). In addition to this we wish to use test beam facilities that will be available at Fermilab in the future to test sub-detectors (for example a calorimeter module built by CALICE) or parts of a completed detector structures in the future. All this work will be done within the international character and framework of ILC detector design efforts. Required resources are roughly \$400K in FY05, growing to roughly \$1M in FY07.

**Linear Collider Central Team of the GDI:** Fermilab has submitted a bid to host the GDI Central Team. This team will be responsible for coordination of the world-wide effort to develop a Conceptual Design Report based on the recommended technology, followed a few years later by a complete engineering design suitable for supporting construction. The CT-GDI is the focal point for the ILC project planning, holding the schedule, major milestones and parameter list. It will provide the intellectual leadership under ICFA guidance and will coordinate the R&D and design efforts of the Regional Teams, while performing its own overall system design tasks.

We believe Fermilab offers a unique combination of physical facilities, technical and administrative support functions, and an intellectual climate appropriate for the development of the design of the ILC. As such we believe our bid will compete strongly. Nonetheless, Fermilab anticipates significant participation even if the GDI-CT is located elsewhere.

## **7. BRIEF DESCRIPTION OF LABORATORY'S ANTICIPATED ROLE:**

*Expected unique capabilities to be provided by lab. Rough estimate of human resources from lab (#FTE in what type labor).*

*See details in points 5 and 6 above.*

