## Chapter 1. Executive Summary: A Plan for Fermilab

The Fermilab Steering Group has developed a plan to keep U.S. accelerator-based particle physics on the pathway to discovery, both at the Terascale with the LHC and the ILC and in the domain of neutrinos and precision physics with a high-intensity accelerator. The plan puts discovering Terascale physics with the LHC and the ILC as Fermilab's highest priority. While supporting ILC development, the plan creates opportunities for exciting science at the intensity frontier.

If the ILC remains near the Global Design effort's technically driven timeline, Fermilab would continue neutrino science with the NOνA experiment, using the NuMI (Neutrinos at the Main Injector) proton plan, scheduled to begin operating in 2011. If ILC construction must wait somewhat longer, Fermilab's plan proposes SNuMI, an upgrade of NuMI to create a more powerful neutrino beam. If the ILC start is postponed significantly, a central feature of the proposed Fermilab plan calls for building an intense proton facility, Project X, consisting of a linear accelerator with the currently planned characteristics of the ILC combined with Fermilab's existing Recycler Ring and the Main Injector accelerator. The major component of Project X is the linac. Cryomodules, radio-frequency distribution, cryogenics and instrumentation for the linac are the same as or similar to those used in the ILC at a scale of about one percent of a full ILC linac.



An open meeting of the Fermilab Steering Group, July 9, 2007. Credit: Fermilab Visual Media Services.

Project X's intense proton beams would open a path to discovery in neutrino science and in precision physics with charged leptons and quarks. World-leading experiments would allow physicists to address key questions of the Quantum Universe: How did the universe come to be? Are there undiscovered principles of nature: new symmetries, new physical laws? Do all the particles and forces become one? What happened to the antimatter?

Building Project X's ILC-like linac would offer substantial support for ILC development by accelerating the industrialization of ILC components in the U.S. and creating an engineering opportunity for ILC cost reductions. It offers an early and tangible application for ILC R&D in superconducting technology, attracting participation from accelerator scientists worldwide and driving forward the technology for still higher-energy accelerators of the future, such as a muon collider.

To prepare for a future decision, the Fermilab Steering Group recommends that the laboratory seek R&D support for Project X, in order to produce an overall design of Project X and to spur the R&D and industrialization of ILC linac components needed for Project X. Advice from the High Energy Physics Advisory Panel will guide any future decision to upgrade the Fermilab accelerator complex, taking into account developments affecting the ILC schedule and the continuing evaluation of scientific priorities for U.S. particle physics. Fermilab should also work toward increased resources for longer-term future accelerators such as a muon collider, aiming at higher energies than the ILC would provide.



## 1.1 Guidelines

The Steering Group adopted a number of guidelines in forming the plan.

1. The LHC program is our most important near-term project given its broad science agenda and potential for discovery. It is essential to support the physics analysis, computing, and accelerator and detector upgrades.
2. The particle physics community's highest priority for investment toward the future is the ILC, based on our present understanding of its potential for breakthrough science. Fermilab will continue to participate vigorously in the international R&D program for the ILC and to be one of the leaders in the global ILC effort. The laboratory will strive to make the ILC at Fermilab a reality by accomplishing the preparatory work required for the U.S. to bid to host the ILC.
3. There is a need for an intermediate science program in case the timeline for the ILC is stretched out. This program will be an opportunity to do exciting physics that complements discoveries at energy frontier facilities and to make further progress on ILC technology. The program should provide great discovery potential, support ILC R&D and industrialization as well as R&D on future accelerators beyond the ILC and the LHC. It should strengthen ties with the university community and with other laboratories. The plan must be robust and flexible.
4. Fermilab will continue a phased program of particle astrophysics including dark matter and dark energy. The program will allow complementary discoveries to those expected at the accelerator-based particle physics programs. These nonaccelerator-based efforts are outside the Steering Group's charge and are not included in the plan.

**1.2 The Steering Group's proposed plan**

The Steering Group recommends the following plan for the accelerator-based particle physics program at Fermilab.

* Fermilab's highest priority is discovering the physics of the Terascale by participating in the LHC, being one of the leaders in the global ILC effort, and to make the ILC at Fermilab a reality.
* Fermilab will continue its neutrino program with NOνA as a flagship experiment through the middle of the next decade.
* If the ILC remains near the timeline proposed by the Global Design Effort, Fermilab will focus on the above programs.
* If the ILC departs from the GDE-proposed timeline, in addition Fermilab should pursue neutrino-science and precision-physics opportunities by upgrading the proton accelerator complex.
	+ If the ILC start must wait for a couple of years, the laboratory should undertake the SNuMI project1.
	+ If the ILC postponement would accommodate an interim major project, the laboratory should undertake Project X for its science capability and ILC alignment2.
* If the ILC is constructed offshore, in addition Fermilab should pursue neutrino-science and precision-physics opportunities by upgrading current proton facilities while supporting the ILC as the highest priority.
	+ The laboratory should undertake SNuMI at a minimum.
	+ Alternatively, the laboratory should undertake Project X if resources are available and ILC timing permits.
* In all scenarios,
	+ R&D support for Project X should be started now, with emphasis on
		- expediting R&D and industrialization of ILC cavities and cryomodules,
		- overall design of Project X.
	+ R&D for future accelerator options concentrating on a neutrino factory and a muon collider should be increased3.
	+ The laboratory should support detector R&D and test-beam efforts for effective use of future facilities.

1 SNuMI is an upgrade of NuMI.

2 Project X consists of an 8 GeV ILC-like linear accelerator and reconfigurations of the existing Recycler and Main Injector. The accelerator portion would be similar in size and scope to the Main Injector. Construction would take four to five years with a few hundred FTEs per year. It would be most effectively mounted as an interlaboratory collaboration.

3 The total annual U.S. R&D budget needed for a neutrino factory and a muon collider is estimated to be approximately $20M.