THE INTERNATIONAL LINEAR COLLIDER

GATEWAY TO TECHNOLOGY

Photo: Fermilab

16,000 superconducting cavities will drive the ILC's particle beams and could be a technology driver as well.

Humankind has always been driven by the desire to understand the world in which we live. The tools invented by scientists to gain this understanding in turn yield applications that benefit all of society and play a major role in the global economy.

Particle physics has been the source of many innovations not originally part of the quest for understanding the Universe. Many of these – medical diagnostics and therapy and the World-Wide Web are two striking examples – have changed the way we live and do business. Particle physicists continue their quest, and history tells us that the tools of the future should be the source of yet more technological breakthroughs, driving progress in industry and securing the workforce of the future. One of these tools is the proposed particle accelerator, the International Linear Collider or ILC.

Using unprecedented technology, the 31-kilometre-long ILC will hurl electrons and their anti-particles, positrons, toward each other at nearly the speed of light to collide 14,000 times every second at energies of 500 billion electron-volts. With the ILC, discoveries are within reach that could stretch our imagination with new forms of matter, new forces of nature, new dimensions of space and time and bring into focus Albert Einstein's vision of an ultimate unified theory.

Fundamental research is not done with the aim to make computers even faster, chips even smaller or medicine even better. We cannot be sure where the research into nature's most fundamental constituents will take us, and likewise cannot be sure what beneficial innovations will emerge. However, the track record makes us confident that technological advances will occur, in one form or another.

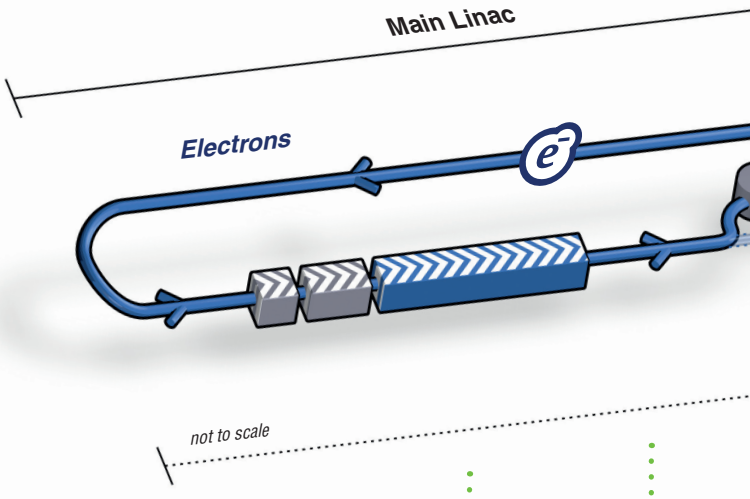
Medicine

Computer-tomography scan of a human head.

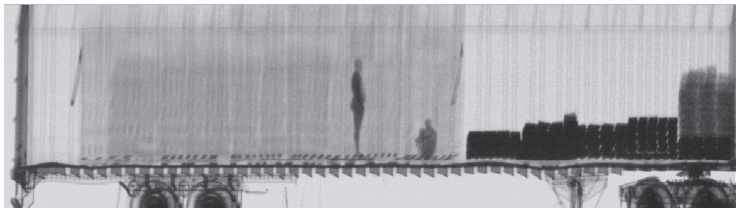
Positron emission tomography (PET), a product of physics research into antimatter, has become an essential medical diagnostics tool, allowing previously unattainable views of chemical processes within live organs. Proton therapy is a powerful treatment method delivering a concentrated, targeted dose of protons precisely to the site of a tumour. Those treatments, however, currently need heavy and costly equipment. The ILC's new superconducting RF accelerating technologies make it possible to downsize the equipment and reduce its power consumption. Radiation therapy could become more focused and thus less damaging to healthy tissue by synchronising to the patient's breathing cycle. The superconducting technology could be adapted to produce monochromatic X-rays for medical diagnoses and treatment, enabling radically new probes of biological processes and tissue protein structure, and help develop new medicines.

POSSIBLE BENEFITS FROM ILC TECHNOLOGY

Challenging technologies are required for the International Linear Collider. Superconducting radio frequency (SCRF) cavities like the one shown on the front page will be used to accelerate particles to high energies. Unprecedented detector technologies will record the particles from the collisions. The whole ILC project is a challenge in terms of super-efficient particle acceleration, squeezing beam sizes to the nanometre scale and tracking particles to unprecedented precision. ILC scientists around the world are studying ways to meet these challenges and industry is preparing to produce high-tech components, some of which will find their way into everyday life.



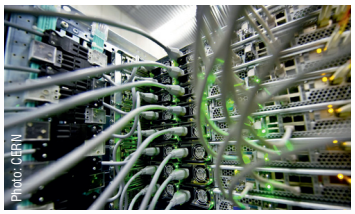
Tools for the future



Gamma-ray image of a cargo container.

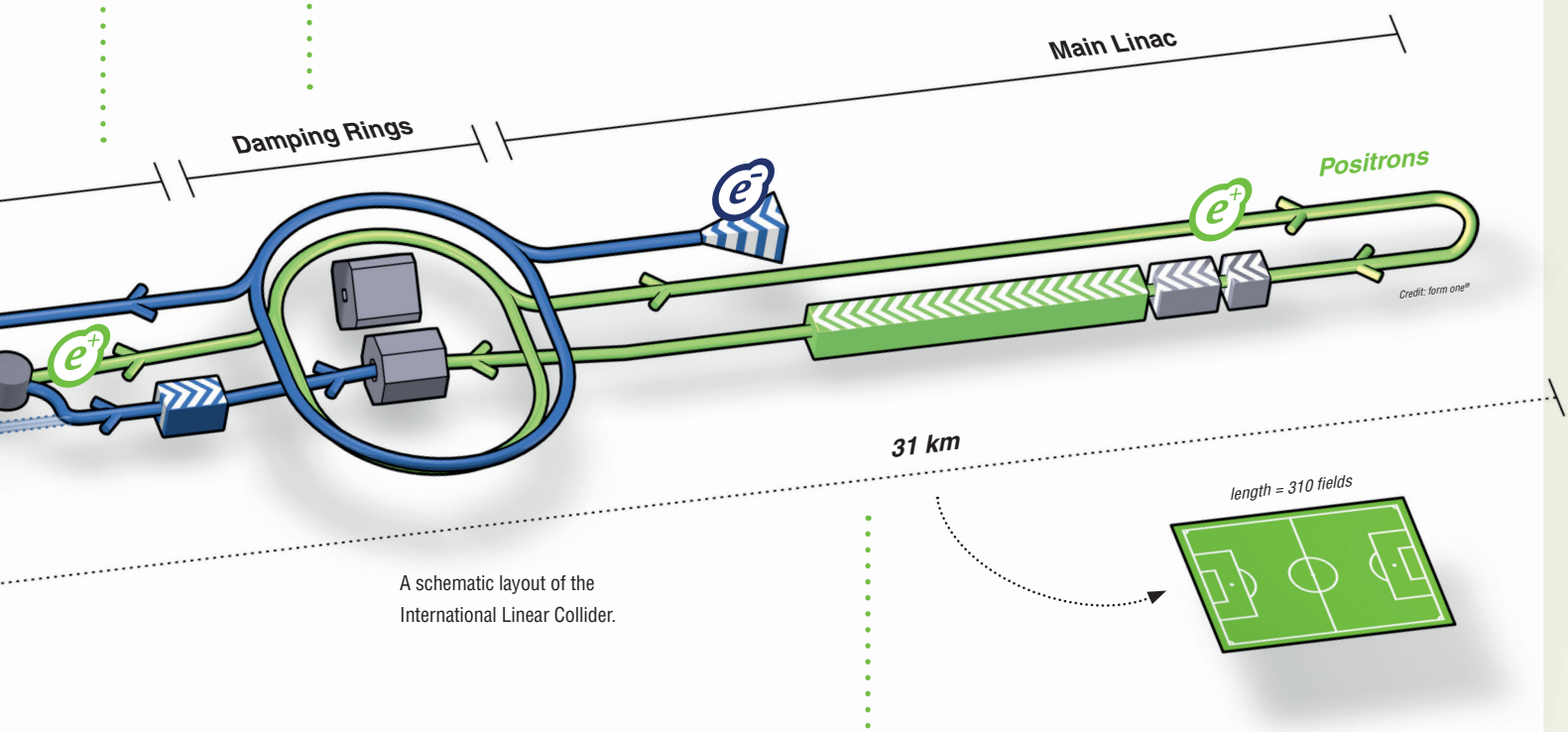
The challenges of a new science project can greatly enhance many different industrial processes, thus driving technological development and the economy. For example, the tiny particle beams of the ILC need constant monitoring and fast, precise corrections. Tools developed for this purpose will help design very highly integrated electron circuit fabrication methods, which will be a major boost to many industrial processes and products at the nanometre scale. PCs could become more compact and lightweight thanks to improved technologies for electron beam lithography. Techniques originally used to give the accelerator's cavities their exquisite polish could lead to cheaper, better understood technologies for the metals industry. The expertise gained in producing 16,000 superconducting cavities and all the parts that drive them is likely to enhance superconducting applications in general. The electron sources developed for the ILC could enable new electron microscopes that would revolutionise the magnetic disk industry. Even customs officers' daily work may benefit from particle physics: with the help of detector technologies developed for particle collisions, cargo containers could be scrutinised very efficiently.

Computing



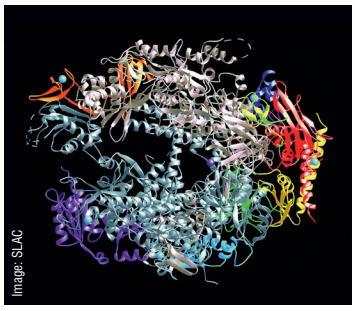
View of a particle physics computing centre.

The data transfer rates from experiments like those at the ILC and the Large Hadron Collider (particle physics' current big adventure) are enormous – comparable to those for all the world's telecommunications put together. The latest computer and communications technologies and the advanced Grid data flow management software developed by particle physicists are essential to cope with the demands, but these now extend more broadly. The MammoGrid database developed in European laboratories distributes mammogram information among participating doctors and hospitals. A repository with 30,000 mammograms is now accessible, helping save lives.



A schematic layout of the International Linear Collider.

ILC Technology and other sciences



Protein structure imaged by X-ray scattering at a synchrotron accelerator.

Superconducting technology should advance work on Energy Recovery Linacs (ERLs), permitting substantial savings in size and cost. The ERLs will significantly expand the capabilities for studies in nuclear science, materials science, chemistry, structural biology and the environment. The first Free-Electron Lasers (FELs) now being built in the US, Japan and Germany are based directly upon linear collider research. Light sources have brought important advances within many sciences over the past few decades leading to many applications. For example, researchers at the Advanced Light Source in the US solved the structure of the avian flu virus and analysed its specificity to human receptors. The ILC technology can also be applied to the acceleration of protons and nuclei. Proton accelerators for intense spallation neutron sources provide a wide range of studies on biological properties. Numerous applications can also be found in material science, with direct implication on everyday life: medical implants, corrosion control, lighter airplanes and many more.

Environment

Superconducting technology could produce intense gamma rays to characterise the composition of nuclear waste. With this knowledge, high intensity neutron beams can be tailored to turn the waste into harmless stable nuclei. An Asian collaboration working in Japan is developing this potential. ILC radiofrequency power systems could enable remote chemical analyses of environmental hazards. Monitoring technologies for precise beam control could be used as a new early warning system for seismic activity.


Photo: KEK

From student to professor, scientists and engineers from all over the world work on the ILC.

PEOPLE AND SKILLS

Over the past four decades, particle physics experiments have become increasingly international. Large collaborations with scientists from around the globe gather to share their expertise and their data. A key benefit from these collaborations is the development of close cooperative working relationships and mutual trust, which may influence the relationships among nations in the long run when the scientists occupy important positions in their home countries.

A much more immediate effect, however, is the diffusion of highly qualified and innovative scientists and engineers into the medical, industrial and commercial sectors of society, bringing new ideas and talent to a broad range of problems. This 'technology transfer of people' has tremendous impact on society generally.

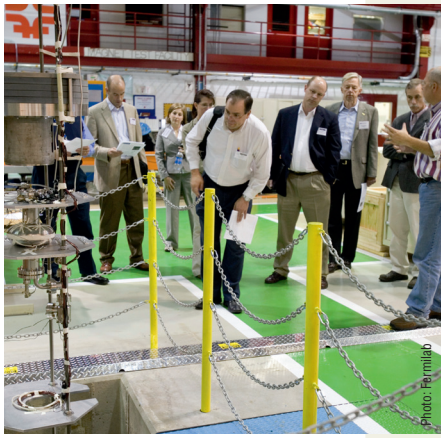


Photo: Fermilab

Members of an Industrial Forum visit an accelerator test facility.

Particle physics has always played an important role in capturing the interest of young people and encouraging them to seek careers in science and technology. The workforce of the future, equipped with the creativity and perseverance to tackle and solve unique and challenging problems, is developing new acceleration techniques and detector prototypes right now. The ILC plays an important role as a magnet to attract the new generation of scientists and engineers that society needs.

Industrial forums are busy in America, Asia and Europe to prepare the local industry for the vast, demanding and rewarding tasks that the ILC will bring.

More information on the web:
http://www.linearcollider.org

Industrial forums for the ILC:
http://www.eifast.eu
http://www.lcfoa.org
http://aaa-sentan.org

This brochure is based on a Technology Benefits report commissioned by the Funding Agencies of Large Colliders FALC. Read the full report here: http://www.linearcollider.org/TechnologyBenefits

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