Industry eyes the next big collider

by Elizabeth Clements

Technology developed for the International Linear Collider could help make nuclear waste safer, cargo inspection easier, and drug design more effective.

symmetry | volume 04 | issue 05 | jun/jul 07

With a blue marker poised at a large white flip chart, Maury Tigner, a physicist at Cornell University, turned to a group of about 10 representatives from industry and asked, "What kind of applications interest your company?" The room was cramped and beige, a generic hotel meeting space, strewn with coffee mugs and crinkled candy wrappers. The setting gave no hint that the discussants were forming a cutting-edge technological vision.

Bill Umbenhaur of Everson Tesla wanted to know more about long-term medical applications. Dean Hoffman of Sciaky was interested in general lab services and machines. Karen Kimball of Parsons described her company's interest in design and construction management.

In other rooms around the hotel, similar groups were also brainstorming. Each was envisioning how components being developed for the International Linear Collider (ILC) could lead to spin-off applications and technologies.

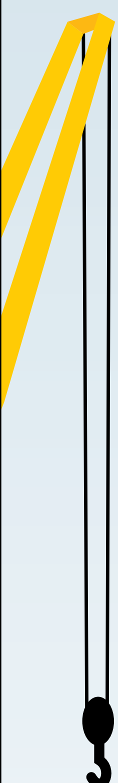
Before the day was out, the group would come up with ideas for decontaminating nuclear waste to make it safer to store, inspecting cargo reliably and rapidly at ports around the world, and performing liposuction by laser.

Imagining potential

Charged with thinking outside the box and fueled with caffeine and sugar, about 40 ILC scientists and people from industry participated in the ILC Technical Applications Workshop on May 15 in Dulles, Virginia. Ken Olsen, president of the 31-member Linear Collider Forum of America, arranged for the industry leaders to attend.

Similar discussions are also taking place in Asia and Europe as part of a study on the technical benefits of the ILC, commissioned by the Funding Agencies for Large Colliders (FALC), which consists of representatives from the world's science-funding agencies. The results will be published in a report this fall, as a follow-up to February's release of the ILC *Reference Design Report*.

Paul Grannis, of the US Department of Energy, is a member of the FALC subcommittee that is conducting the study. "There is a well-understood set of scientific goals for the ILC, and the impact of ILC technology on other scientific facilities will be large," he said. "There also needs to be a case outlining the possible practical applications, without overstating their potential. Some of the immediate benefits can be rather clearly seen; the longer-term applications are harder to foresee, but they are perhaps the most rewarding."



Superconducting technologies

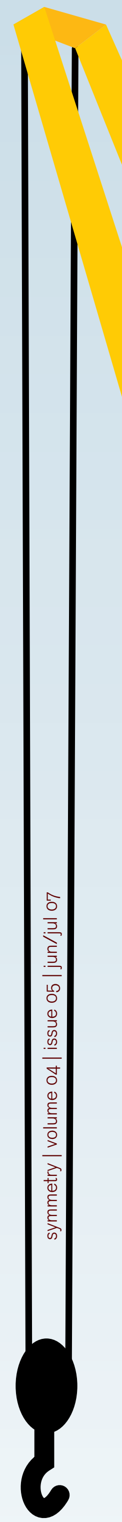
The subcommittee envisions potential applications both in industry and in other branches of science, following a long tradition in which accelerators developed for high-energy physics find novel applications in materials science, chemistry, biology, and environmental science. The upcoming FALC report, intended for an industrial audience and focusing on the broader societal impacts, will be used to bring these technological benefits to the attention of governments.

The Department of Energy already recognizes that superconducting technology will have wide applications, and included $23.5 million specifically for superconducting radiofrequency cavity (SRF) research and development in the FY2008 budget request.

Although SRF technology has been studied for decades, it is still considered relatively new, with ILC scientists making significant improvements and cost savings as they develop it for use in particle accelerators.

Radiofrequency cavities are used to boost the speeds of particles in accelerators. They're filled with huge electrical fields that oscillate, producing pulses of energy that push the particles along. When chilled to near absolute zero, their superconducting metal walls conduct electric current with almost no loss of energy, and this efficiency makes the technology appealing.

Higher accelerator fields and improved efficiency can translate into smaller, not to mention cheaper, packages. "We are just starting to come up with ideas for superconducting technology applications now because it is so new," says Tigner. "With some good engineering, we could do a lot to minimize the size of the apparatus and harness its potential for uses in medical or industrial applications."



Proteins, liposuction, and nanotubes

One beneficiary is the X-ray free electron laser, which uses the same kinds of superconducting cavities that the ILC will. It produces super-fast pulses of X-rays that can be used to make movies of chemical reactions and molecular processes in action.

"Imagine being able to see how a drug is changing the molecular structure of proteins in real time," said Fermilab's Shekhar Mishra. "This will give the scientists a unique tool to create pharmaceuticals that can fit the shape of a certain human biological molecule and thereby deliver their effects in a very specific way."

Another possibility: non-invasive liposuction. Working with Thomas Jefferson National Laboratory's free electron laser, a Boston dermatologist discovered that fat cells absorb different wavelengths of energy than other body cells do. By tuning the laser, he was able to selectively destroy fat cells under the skin.

Researchers at JLab are also exploring ways to use the free electron laser to produce large quantities of carbon nanotubes, super-strong cylinders with many potential applications.

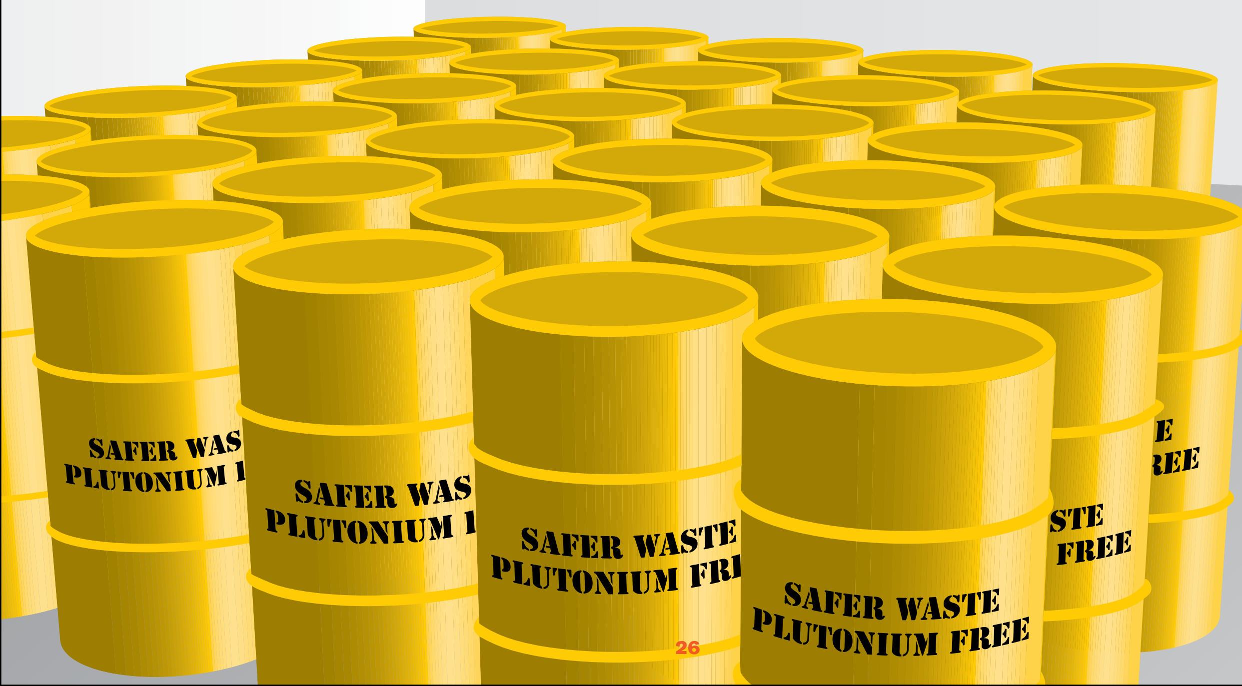
"We have established the feasibility of some of these things," says Warren Funk, former director of JLab's Institute for SRF Science & Technology.

Safer nuclear waste

One ambitious topic of discussion was the possibility of transmuting nuclear waste—changing it into a more stable form that is less hazardous—using a high-powered proton beam from a superconducting linear accelerator. The process would extract nearly all the available energy from nuclear waste, leaving virtually no plutonium behind. The resulting residue would require special storage for a few hundred years, compared with a few hundred thousand years for waste containing plutonium, greatly simplifying the engineering needed to store it safely.

The proton beam would hit a heavy-metal target at the center of the nuclear waste or spent fuel, and pound it with 10-100 megawatts of power. Each proton that hit the target would liberate dozens of neutrons that bombard the nuclear waste, breaking down the remaining uranium and plutonium to shorter-lived fission products.

As a bonus, the process could create a few billion watts of electrical power to run the accelerator, and have a lot left over to sell to power companies. "This should be attractive to a world simultaneously concerned



about the production of greenhouse gases through our reliance on fossil fuels and about the spread of nuclear weapons," Funk says.

The challenge would be shutting the process down and starting it up again rapidly; but the group agreed that this might be a solvable engineering problem.

Cargo scanning

Off in another meeting room, the detector subgroup discussed cargo scanning. A high-power beam of gamma rays from a superconducting linear accelerator could probe a shipping container, exciting the atoms and nuclei inside. Detectors being developed for the ILC would measure the resulting emissions, rapidly fingerprinting the material to spot contraband or nuclear weapons.

What's more, since the detector technology used for the ILC is capable of producing a tomographic image, it would reveal the full three-dimensional shape of the objects inside. An alternate scheme using the deflection of naturally occurring cosmic rays is also being investigated.

"These devices could be small," Tigner said. "There would also be a high demand for companies to make a high number of them. Demand is always key to whether a given application is useful or not."

Beyond commercial products

Beyond such gee-whiz applications, scientific instruments like the ILC also promise wider impacts on society—particularly when it comes to training the next generation of scientists, engineers, and technicians.

Manufacturing the required 16,000 superconducting cavities, digging the 72 kilometers of tunnel complex, and wiring the 600 radiofrequency power units needed for the ILC will require a multitude of skilled workers drawn from other areas. Terry Grimm of Niowave, Inc., a company in Lansing, Michigan, that specializes in manufacturing superconducting cavities, hires technicians from the area's declining auto industry to craft metal parts. "The high-tech metal-forming industry in this area makes it very easy to find people," he says.

Creating new jobs is one outcome; inspiring young people is another. Karen Kimball, a vice president at Parsons who participated in the workshop, believes this hope is the real inspiration for finding technical applications. "The ILC will create an opportunity to excite young people and inspire them to pursue science," she says. "To me, that is the real motivating factor."