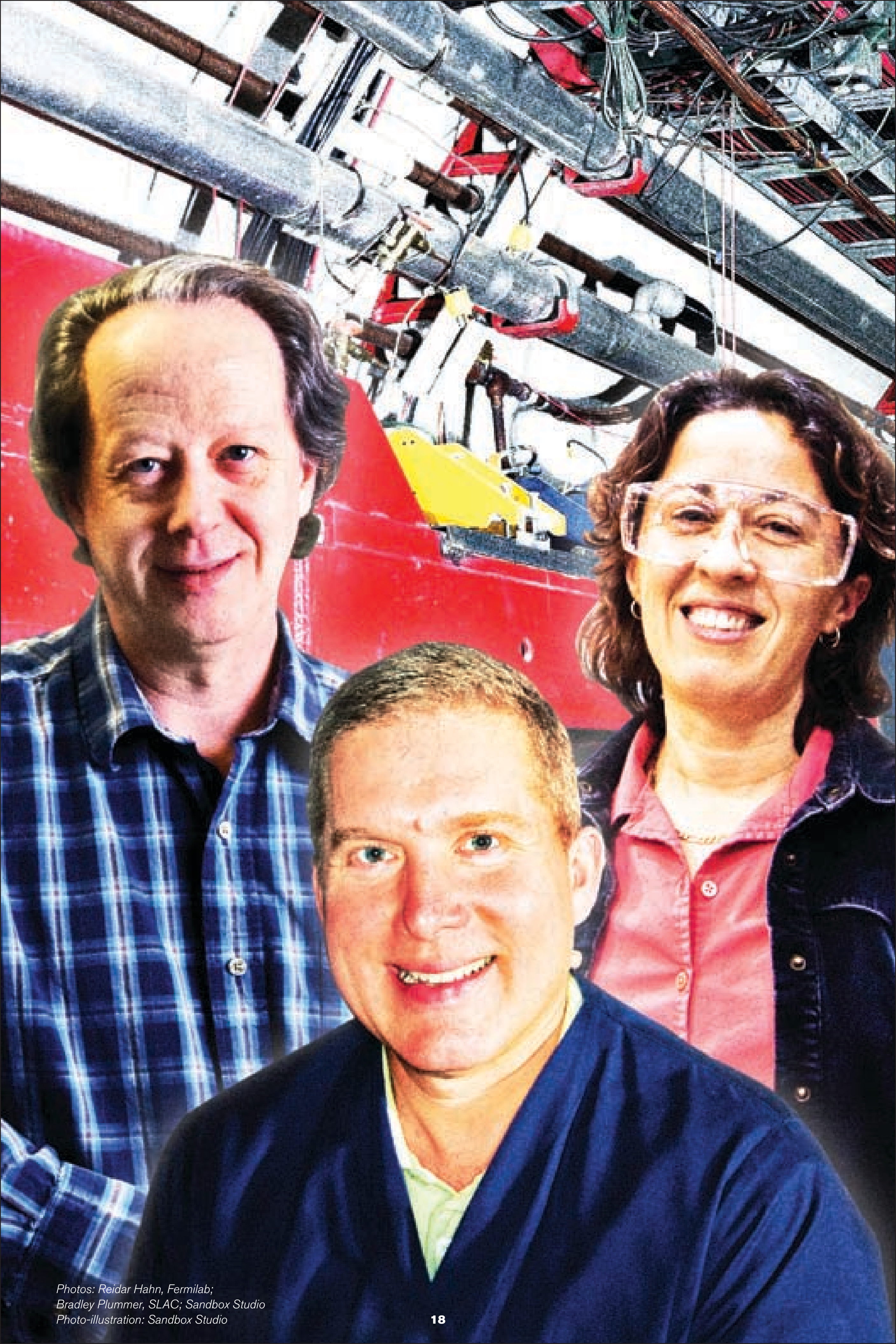


Photos: Reidar Hahn, Fermilab;
Bradley Plummer, SLAC; Sandbox Studio
Photo-illustration: Sandbox Studio

A fearlessly creative workforce

By Tona Kunz

Many of the people trained in particle physics move on to jobs in industry, where their skills are in high demand. There you can find a theorist exploring for oil or an accelerator scientist working on cancer treatments.

Theoretical physicist Jorge Lopez was looking forward to working with the world's largest atom smasher—the Superconducting Super Collider, then under construction in Texas—when Congress pulled the plug on the project in 1993. With the biggest opportunity in his field gone, he decided to give industry a look.

At his first job interview, he found himself explaining his work on string theory—a theory that attempts to unify all the fundamental forces but requires at least 11 dimensions, rather than the four currently observed—to a Shell Oil representative.

To his surprise, this esoteric chat didn't sabotage the interview.

"I got a job offer that day," Lopez says. "I guess I impressed them as someone who could address different problems and solve them. I've met a lot of people who have similar stories to mine, and some even work on my team."

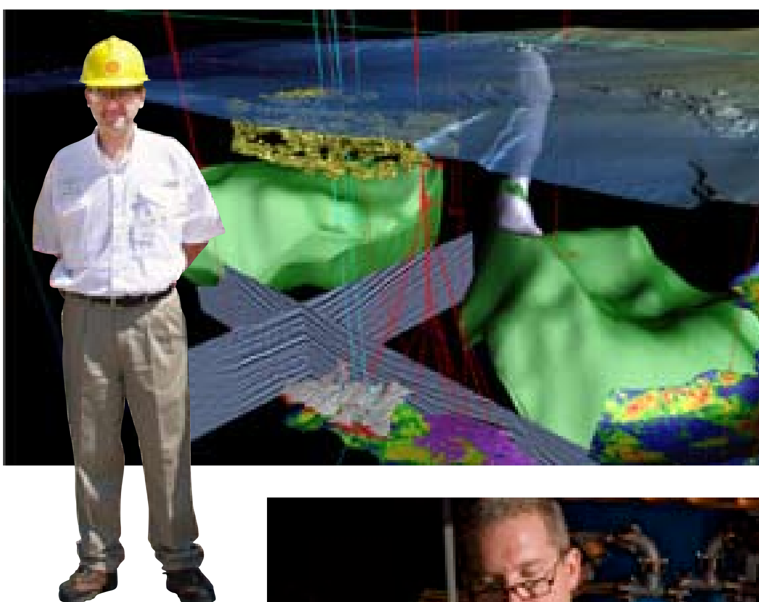
Unbeknownst to many, high-energy physics serves as a training pipeline for industries such as medicine, security, and finance that touch everyday lives.

Rather than mourn this migration of physicists, engineers, and computer analysts into the broader society, the field sees it as added value—a way to give back to taxpayers and the community.

"People may be your most important product," Michael Holland, who reviews science projects for the US Office of Management and Budget, told employees and users at Fermilab in June. "They create an important element of the national innovation system."

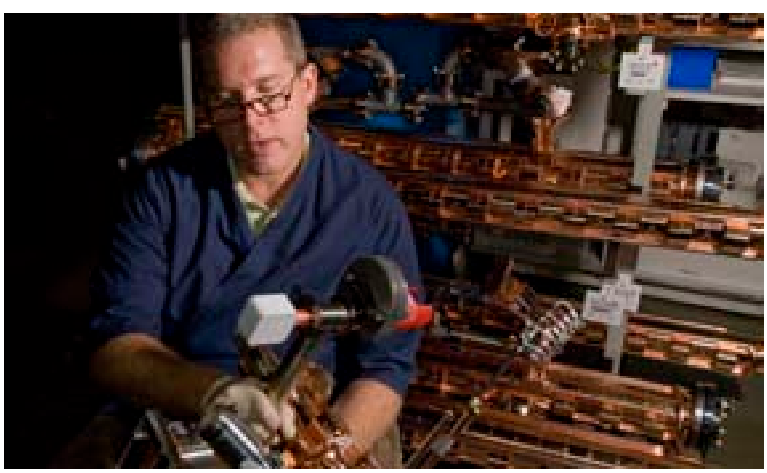
A unique training ground

High-energy physics provides training not found elsewhere: collaborating with hundreds of scientists all over the world; designing cutting-edge tools; working with machines much too large and expensive for any one university to build; and grappling with mathematical equations and abstract concepts on the edge of current understanding.



In his job at Shell Oil, Jorge Lopez (left) of Texas uses critical-thinking skills he learned as a theoretical physicist to develop 3-D integrated modeling programs such as the one behind him, which shows the Gulf of Mexico. This helps the oil company find the safest and most economically viable areas to drill.

Photo and modeling image courtesy of Jorge Lopez



Dave Whittum (right) works for Varian Medical Systems in California, designing accelerators like the one he's holding for cancer treatment and cargo scanning.

Photo: Bradley Plummer, SLAC

Just how large an impact this has on the workforces of other fields is difficult to assess. Anecdotes from former physicists and their employers abound; concrete statistics do not.

Yet in a time of shrinking federal funds and stiff competition for research investment, policymakers want to know: Does the "big bang" science offer a wider-reaching bang for the federal buck?

Increasingly, Congress is asking where people who have trained in the field go on to work, says Usha Mallik, a physicist at the University of Iowa who is involved in efforts to track physics graduates.

"It is not everyone who becomes a high-energy-physics professor or a researcher at Fermilab," she says. "From looking at past surveys and listening to anecdotes from professors and laboratories, a tremendous number of high-energy-physics students go into industry. Some go into government. Some even go on to Wall Street."

Finding oil, treating cancer

Lopez is a case in point. He taught physics at Texas A&M and Rice universities. He worked with Fermilab's DZero experiment when it discovered the top quark in 1995. Now he helps Shell Oil tap into hard-to-reach oil fields, and leads an international team developing new technology to monitor the oil and gas that fields contain.

"You want to place a drill bit where you have the most chance of success, the least expense, and optimal safety," he says. "All of the knowledge I have from basic physics is applicable today"—in particular, the concept of using computer models to test theories and simulate how equipment will work.

"We are always looking for people who can think creatively," Lopez adds. "Here we have a lot of physicists."

David Whittum used to teach students at Stanford University how to design microwave linear accelerators for research at Fermilab and SLAC National Accelerator Laboratory. Now with Varian Medical Systems in California, he develops accelerator-based tools for treating cancer. The technology also has potential for scanning cargo to find bombs.

Katherine Harkay uses skills honed in particle accelerator classes to improve the quality of the brightest X-ray beams in the Western Hemisphere—the Advanced Photon Source at Argonne National Laboratory. Scientists use those beams in studies aimed at engineering heartier crops, developing more effective medications, designing better fuel injectors for vehicles, and building more durable industrial materials, to name a few examples.

"The applications for the science done with the X-rays—measuring chemical reactions over time and imaging the structure of material at the smallest scale—are directly related to people's lives," Harkay says.

More than 50 lightsource facilities exist across the globe, with more in the planning stages. Yet university programs in accelerator physics don't produce enough scientists to support the field. Particle physics laboratories and the US Particle Accelerator School help fill the void, Harkay says, supplying the knowledge and manpower needed now to have the next generation of light sources ready in a decade.

Fearless creativity

Physicists find that their creativity, critical thinking, and training in mathematical analysis lend themselves to addressing energy issues, tracking risk for insurance agencies, and predicting fluctuations of the stock market. Some move into the computer and technology industries.

Every accelerator is uniquely made for the experiment it supports. Often they are their own prototypes, forcing those who use and maintain the machines to think outside the box to increase efficiency and fix unanticipated breakdowns. The result is not only a good experimental tool but also a creative, fast-thinking workforce.

And because high-energy physics projects can take years or decades to plan and build, scientists and engineers must design technology well beyond the current generation; otherwise it will become outdated before the experiment starts.

Joseph Dehmer, director of the Division of Physics for the National Science Foundation, told Fermilab employees in June that the need to measure the smallest constituents of matter makes particle physics stand out from other sciences.

"Particle physicists are the most fearlessly creative group of people I know," he said. "If the technology doesn't exist to do a measurement, the particle physics community is not bothered by that. They just create it." This need for precise measurement, he said, drives technological innovation.

John Brining is executive director of the Illinois-based Construction Industry Service Corporation, which promotes union construction and brings contractors together with skilled laborers. He says contractors specifically seek out people who have worked at Fermilab in areas from general construction to electrical and maintenance. "Fermilab has been an important component of construction in Chicago over the years," he says.

Paul Mantsch, who as long-time head of the lab's Technical Division oversaw workers in the machine shop, says, "These people are highly skilled, so once they leave Fermilab it is very easy for them to find jobs. They work here a while and then they go out to industry. We feel that is fine. We are a taxpayer-funded industry so helping the community is one of our missions."

A faint, sporadic trail

Fewer than 10 percent of particle physics students entering US graduate schools can expect to attain tenured academic positions in related fields, according to a report Mallik wrote for the High Energy Physics Advisory Panel, or HEPAP. It was based on data from a 2007 survey of the field.

Where the remaining 90 percent end up is less clear.

The American Physical Society tracks physics graduates, but does not break out statistics for specialties such as high-energy physics. According to the APS initial employment report for 2004—the most recent available—about two-thirds of people with bachelors' degrees in physics and half of those with physics PhDs find their first permanent jobs in the private sector.

"A lot of people do their PhD thesis on accelerator work because it's a great training ground, and then go on to work in industry," says Mike Syphers, who teaches at the US Particle Accelerator School. Based at Fermilab, the school is held about twice a year at universities across the country and overseas. It has trained more than 3000 people from more than 25 nations in accelerator technology and design since 1987. Participants have backgrounds in physics, engineering, the military, medicine, and life sciences.

The accelerator school also has difficulty tracking former students, Syphers says: "They jump between jobs, fields, or locations, and they don't just jump one time—they jump two or three times, and we lose track of them."

Building a better survey

The US Department of Energy began surveying universities and laboratories in 1995 to find out where particle physicists went. But a lack of uniform recordkeeping limited the agency's ability to see clear trends, Mallik says.

Some institutions didn't complete the whole survey form. Some counted summer students, engineers, or computer programmers as physicists. Few listed the specific industries physicists moved to, and many lost track of graduates after their first jobs.

But that is changing.

In 2003, HEPAP formed a demographics survey committee to fine-tune both the survey and the system for tracking people trained as high-energy physicists.

During the last few years, Mallik has worked with Mike Ronan and Bill Carithers of the University of California, Berkeley, to find gems of information in a mountain of previously generated DOE data. They created a more user-friendly survey for 2008, along with software to cross-check the data and look for inconsistencies in it. Mallik's next goal is to track individuals by ID number as they move through specific institutions, labs, and industries.

Katherine Harkay (right) does research aimed at improving accelerated electron beams at Argonne National Laboratory's Advanced Photon Source. The photon source is a multipurpose tool used to improve drug design and other consumer products, as well as for basic research.

Photo: Sandbox Studio

Mike Syphers (left) teaches accelerator science not only to physicists, but also to people working in medical, military, and manufacturing fields.

Photo: Reidar Hahn, Fermilab

"The census has been vastly improved since the committee got involved, and a work plan has been established," she says. "After a couple of years of vigilance, the quality of the census data will improve."

Passing the torch

Some of those who leave high-energy physics labs for other careers find ways to stay connected to their first love, whether by selling parts to the labs or teaching at the US Particle Accelerator School.

Harkay, for instance, who works in the related field of photon science at Argonne, says the school's classes "were certainly useful for my entry into accelerator physics." She occasionally returns to teach at the school to give others the educational boost that she got.

Whittum also teaches at the accelerator school. And as Varian's manager of microwave applied research, he sends all the company's engineers who work on accelerator manufacturing to study there.

Varian's development was driven, in part, by the demands of high-energy physics. It has adapted accelerator technology for cancer treatment and for screening technology that can penetrate through steel four times farther than previous methods, improving weapons detection and the ability to inspect cargo at ports.

The efficiency of these machines depends on the quality of their accelerator components, and the US Particle Accelerator School is one of the few places where engineers can get a continuing education in the technology.

"The accelerator schools preserve an important body of knowledge," Whittum says. "In the United States, there are not many people who are doing accelerator design for academia or industry. It is a benefit to society that you share this knowledge."