

Fermilab looking into the smallest things

By Jim Nowlan

As I scribble a note for this column, I am standing 350 feet underground at a research experiment that is sending beams of trillions of neutrinos underground to a detector located 500 miles away in Minnesota.

I am at the Fermi National Accelerator Laboratory (Fermilab) in west suburban Chicago, where Big Science—and big achievements—are the hallmark of the sprawling lab.

Illinois has two national laboratories out of 17 in the country that are operated by the U.S. Department of Energy—Argonne in southwestern suburban Lemont is the other.

Together the labs expend more than a billion dollars a year and employ 5,000 people, about half of whom are scientists and engineers.

Between 1983 and 2011, Fermilab was home to the world's largest particle accelerator and collider, the Tevatron. Scientists used Tevatron to discover, among other things, the top and bottom quarks, subatomic particles that are important building blocks of nature.

But in 2012, a larger collider began operating in Switzerland. The Large Hadron Collider at Europe's particle accelerator lab, CERN, diminished the role of Fermilab, although the lab's scientists work intimately with CERN on experiments.

This generated soul-searching and angst at Fermilab, which needed a new flagship mission.

The lab's leaders decided to become the world leader in neutrino research, which they feel represents the next big frontier in particle science.

Neutrinos are among the most abundant particles in the world. Each second, trillions of neutrinos pass through our bodies. But neutrinos interact so rarely with other particles that they are very difficult to detect.

The Standard Model for understanding particles had predicted that neutrinos would not have mass, but researchers in Japan and the U.S., including at Fermilab, have shown that the tiny particles do indeed have some mass.

This has possibly profound implications for the Standard Model, which may need amendment in order to accommodate the finding that neutrinos have mass.

So neutrino research is a hot field for efforts to understand the creation of the universe.

In addition to neutrino research already underway at Fermilab, the lab is pushing for a \$1.5 billion Long-Baseline Neutrino Facility, which would send streams of neutrinos (underground, no tunnel needed) more than 1,000 miles to a detector in South Dakota.

Because the U.S. government cannot fund this entire project, an international consortium of European and other nations is proposed. The project is not a done deal.

Fermilab is pushing ahead on other fronts as well. For example, only 4 percent of the universe is visible. The rest comprises dark energy and dark matter.

Lab scientists designed and built a dark energy camera of 570 megapixels that takes images on a telescope in Chile. The lab is also a leader in experiments that seek to capture particles of mysterious dark matter.

This is all pure theoretical and experimental science. The practical benefits to society come primarily from the technological innovations developed to aid the quest to understand the universe.

For example, a fact sheet from Fermilab notes that the World Wide Web was created by particle physicists who wanted to communicate their research findings more efficiently.

And a scientist at Fermilab believes that portable particle accelerators can be used to seal highways to make them last longer.

Illinois fares poorly in terms of federal grants distributed to the states, ranking 38th in 2010 (the last year the government published the data) at \$1,874 per capita versus a national average of \$2,183.

If we were at the national average, we would receive about \$3.7 billion more a year in federal grants. For example, because of an old formula, the federal government compensates Illinois at 50 percent of costs in the multi-billion dollar Medicaid program, whereas neighboring states are reimbursed at about 63 percent of their costs.

Thus it is all the more important that we work to sustain the health and productive futures for our state's national laboratories.

Big Science generally, not always, operates above the fray of practical politics.

But it never hurts to tell our congressmen and women how invaluable we consider the work of our laboratories.