10. PRACTICAL BENEFITS

The knowledge gained from high-energy physics research is used not only in other scientific fields but increasingly in advanced technology and engineering. Although the principal aim of this research is to understand the fundamental nature of matter and energy, the information gained often has immediate practical applications. Large markets may take decades to emerge, but so-called spin-offs—positive effects such as new products, quality improvements, and productivity increases—take place every year. And high-energy physics often serves as a proving ground for risky new technologies not yet ready for the marketplace.

Often, it takes years for the results of basic research in particle physics to find mass applications. The particle physics of the 1920's, which led to quantum mechanics and a precise theory of atomic structure, was crucial to the invention of the transistor and lasers in the 1940's and the 1950's. Hardly a decade elapsed, however, between the first experiment on controlled nuclear fission and its use in submarine propulsion. One cannot say for sure how soon technological advances will come from recent research in high-energy physics, but history suggests it will not be long.

Money invested in high-energy physics research also produces more immediate benefits to society. In the course of their work, researchers develop devices, instruments, and technologies that can be used for practical purposes outside the domain of pure research; most frequently these applications occur in the area of medical diagnosis and treatment. And by working hand in hand with various industries to develop state-of-the-art equipment, high-energy physicists help them improve their processes and speed technology to the marketplace.

Advanced medical technologies have traditionally been quick to take advantage of high-energy physics research. Particle beams, for example, find widespread use in cancer therapy. Electron accelerators using linear accelerators like those developed for the Los Alamos Meson Physics Facility in the 1970's, were quickly developed into clinical instruments by commercial vendors. They and other machines using concepts developed for physics accelerators, are employed in nearly 1,000 hospitals around the United States. Intense beams of x-rays and gamma rays produced by these devices are crucial for radiation therapy. The production and use of these devices is a multi-billion dollar industry.

While energetic photons from these machines are a good choice for treating most cancers, other particles are better for more localized treatments. Focused beams of pions, protons, and heavy ions supplied by cyclotrons or small synchrotrons provide the sharper scalpel needed in such cases. The energies of these charged particles can be adjusted to pass through the skin and outer tissues and deposit most of their energy at a specific depth within the body without unduly harming the healthy surrounding tissue.

Energetic beams of protons have become the preferred treatment for tumor growths inside the eye (ocular melanomas), with a 95 percent success rate. These particles spare the sensitive tissue of the eye and the optic nerve, preserving the patient's vision. Loma Linda University Medical Center, in southern California, has a proton therapy facility containing the first particle accelerator built specifically for proton beam therapy. With a machine designed and constructed by Fermilab, which helped pioneer this treatment during the 1970's, the Center is expanding the technique to all body sites and to many more patients. Japan, Sweden, and the Soviet Union have also begun to use proton therapy extensively.

Beams of charged ions (atoms with less than their full complement of electrons) heavier than protons provide still sharper scalpels. Heavy ions do even less damage in passing through healthy tissues and deposit almost all of their energy when they finally come to rest. By adjusting the initial energy, doctors can tune the ion beams so that they stop precisely in the tumors they wish to excise.