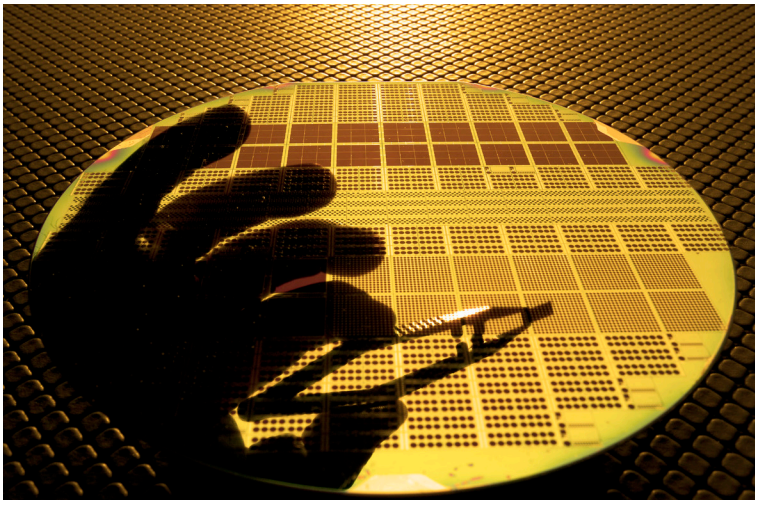
Particle Physics: Benefits to Society

From particle accelerators to the World Wide Web, and from medical imaging techniques to high-performance computing, the bold and innovative ideas and technologies of particle physics have entered the mainstream of society and helped transform the way we live.

Particle physics research pushes the frontiers of knowledge and technology. The development and construction of particle accelerators, particle detectors and other research tools has led to many benefits to society.

The invention of the World Wide Web, the use of particle accelerators to treat cancer and contributions to the development of medical imaging techniques such as PET scans and MRIs are among the better known examples of particle physics innovations. But particle physics has myriad lesser-known impacts. For example, few people have probably heard that low-energy electron beams from particle accelerators provide an environmentally friendly way of sterilizing food packaging.

There are more than 30,000 particle accelerators in operation around the world today. They shrink tumors, make better tires, spot suspicious cargo, clean up dirty drinking water, help design drugs, discover the building blocks of matter, and do much more.



Experts estimate that medical accelerators have treated more than 30 million people around the world. The market for medical and industrial accelerators now exceeds $3.5 billion dollars a year.

Particle detectors first developed for particle physics are now ubiquitous in medical imaging. The technology for PET scans came directly from detectors initially designed to sense photons.

Digital electronics now depends on particle beams for ion implantation and created a $1.5 billion annual market for ion-beam accelerators. The products that are processed, treated or inspected by particle beams have a collective annual value of more than $500 billion.

Ten thousands of scientists, engineers and technicians who were trained in particle physics have gone on to apply their knowledge in medicine, computing, industry, homeland security, research and other areas of society. The next page highlights examples of their innovations.

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Medicine: cancer therapy

Every major medical center in the nation uses accelerators producing X-rays, protons, neutrons or heavy ions for the diagnosis and treatment of disease. It is estimated that there are over 7,000 operating medical linacs around the world that have treated more than 30,000,000 patients. Fermilab built the first hospital-based accelerator to treat cancer, located at the Loma Linda University Medical Center.

Medicine: diagnostic instrumentation

Particle detectors are ubiquitous in medical imaging. Positron emission tomography, the technology of PET scans, came directly from light-sensing detectors initially designed for particle physics experiments. Gamma-ray detectors designed by particle physicists now reveal tumors in dense tissue.

Homeland security: monitoring nuclear waste nonproliferation

In nuclear reactors, the amount of plutonium builds up as the uranium fuel is used. Because plutonium and uranium emit different kinds of particles, a particle detector can be used to monitor and analyze the contents of the nuclear reactor core. A prototype detector already demonstrated the potential use of this new monitoring technology.

Industry: power transmission

Cables made of superconducting material can carry far more electricity with minimal power losses than conventional cables. They offer an opportunity to meet increasing power needs in urban areas where copper transmission lines are near their capacity. Fermilab's partnership with industry to develop the mass production of superconducting wire for the Tevatron accelerator jump-started this industry.

Industry: biomedicine and drug development

Biomedical scientists use the intense light emitted by synchrotron accelerators to decipher the structure of proteins, information that is key to understanding biological processes and healing disease. A clearer understanding of protein structure allows for the development of more effective drugs, such as Kaletra, one of the world's most-prescribed drugs to fight AIDS.

Computing: the World Wide Web

Particle physicists developed the World Wide Web to share information quickly and effectively with colleagues around the world. Few other technological advances in history have more profoundly affected the global economy and societal interactions than the Web. In 1991–92, SLAC, MIT, and Fermilab launched the first Webservers in the United States. In 2001, revenues from the World Wide Web exceeded one trillion dollars, with exponential growth continuing.

Computing: the Grid

The Grid is the newest particle physics computing tool that allows physicists to manage and process unprecedented amounts of data across the globe by combining the strength of hundreds of thousands of individual computing farms. Industries such as medicine and finance are examples of other fields that also generate large amounts of data and benefit from advanced computing technology.

Discovery science: synchrotron light sources

Researchers use the ultra-powerful X-ray beams of particle accelerators known as synchrotron light sources to create the brightest light beams on Earth. These luminous sources provide tools for such applications as protein structure analysis, pharmaceutical research, materials science and restoration of works of art.

Industry: understanding turbulence

From long-distance oil pipelines to models for global weather prediction, turbulence determines the performance of virtually all fluid systems. Silicon strip detectors and low-noise amplifiers developed for particle physics are used to detect light scattered from microscopic particles in a turbulent fluid, permitting detailed studies of this challenging area.

More Information

More examples of particle physics applications
www.symmetrymagazine.org/science-topics/applied-science
Accelerators for America's Future
www.acceleratorsamerica.org