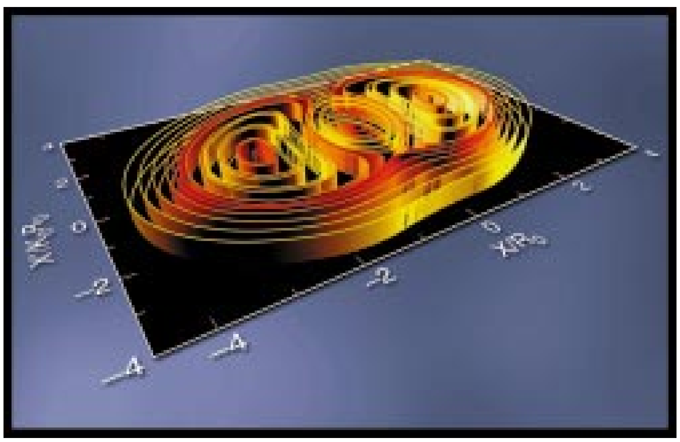
Computational Needs for Future Accelerators

Charged–particle accelerators are fundamental tools used for a broad spectrum of important research and development in all four of DOE's mission areas: science, energy, national security, and environmental restoration. In the science programs they are central to a large fraction of the work that includes the giant accelerators of the High Energy and Nuclear Physics (HENP) Program, the synchrotron light sources and the spallation neutron sources of Basic Energy Sciences, Biological and Environmental Sciences, and the Fusion Sciences. In the energy area there are the neutral beam injectors of the plasma fusion program and the heavy ion drivers of the inertial confinement fusion program. In the national security area there are the neutron sources, flash radiographic systems and pulsed-power systems. In the environmental restoration area, increasing use is being made of the synchrotron light sources. Accelerators for transmutation of nuclear waste are under consideration. There are many other applications of accelerators and accelerator science that extend far beyond the broad mission of the DOE. These include such things as electron microscopy, proton microprobes, charged-particle beam lithography, ion implantation, medical isotope production, radiation therapy, x-ray lithography, and free-electron lasers.



Computer modeling and simulation have been a key element in the design and understanding of all modern accelerators. Computer programs have been written and used to study a wide variety of problems ranging from microwave component design to the long-term stability of particles in nonlinear magnetic fields. This modeling has been as sophisticated and extensive as the available computers would support, and has allowed the development of far more complex and innovative accelerators of all energies as computer capabilities have increased.

The interplay between simulation, experiment, and theory has been of great importance. Together they have provided a framework for calculation, design, verification, discovery, and understanding The Strategic Simulation Initiative (SSI) offers dramatically new levels of performance and capability for accelerator modeling and simulation which could qualitatively change the complexity of the physics incorporated and greatly extend the scale of the problems studied. Components could be designed with significantly improved performance and cost effectiveness, and accelerator simulations might eventually approach the level of a complete accelerator system. SSI could result in significant reductions in design cost and time for particle accelerators for high energy and nuclear physics, could also open up new applications in material science, biology and medicine and have broad impact an accelerator devices used in industry.