High Energy and Nuclear Physics

The field of High Energy and Nuclear Physics (HENP) will soon be acquiring more experimental data, and with it more chances to observe new phenomena and make new discoveries. DOE projects nearing completion are the BaBar detector at the SLAC B-Factory, new experiments at Brookhaven Relativistic Heavy-Ion Collider (RHIC), upgraded experiments at the Fermilab Tevatron, and at Jefferson Lab. These experiments, as well as U.S. participation in the Large Hadron Collider at CERN in Geneva, have the opportunity to increase knowledge of the physical world in unprecedented ways, through unprecedented amounts of data. The volume of data, however, absolutely demands new computer science tools for data management at scales previously unheard of. The Strategic Simulation Initiative (SSI) will provide the cross cutting computational infrastructure to propel science to new levels and scientists in HENP can help given their background in data management.

But answers to fundamental questions about the nature of the universe will not simply leap out from these laboratories. They will be subtly hidden in the raw data. Large-scale numerical simulations of theoretical models are needed to compare data with theory, test the Standard Model and exciting new physics beyond it. These simulations will require computing power of the scale envisioned for SSI to allow theorists to discover new possibilities.

Beyond the upcoming generation of experiments, other future facilities will be needed. SSI offers dramatically new levels of performance and capability for accelerator modeling to design compact, high-energy accelerators of the future, involving 3D geometry and large beam-generated fields, for example. Components could be designed with significantly improved performance and cost effectiveness, and accelerator simulations might eventually approach the level of a complete accelerator system. HNEP has a long history of designing and building their own supercomputer systems to support their studies, so physicists can make valuable contributions.

Collaborations increasingly involve geographically distributed colleagues. Current and planned network capabilities will free researchers from the need to be physically located near their data or computers. Hardware and software tools to facilitate effective collaborations at a distance and the network capability to sustain them are crucial for sustaining synergy among highly motivated researchers.

At the end of the 19th century, J. J. Thompson measured the electron and developed his “plum-pudding” model of the atom. At the end of the 20th century, we have the Standard Model but some tantalizing questions. With SSI computational science ability, high energy and nuclear physicists can make unprecedented advances in the next century.