Space RAD Health Newsletter

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Dedication of NASA Space Radiation Laboratory, October 14, 2003

A crowd of nearly 200 gathered in a festive tent on a bright Fall day to mark the official opening of the newly completed NASA Space Radiation Laboratory (NSRL) on the campus of the Brookhaven National Laboratory (BNL), Upton, New York. The crowd, which included employees of BNL, the U.S. Department of Energy (DOE), and NASA, and researchers from institutions across the country, was welcomed to the ceremony by Dr. Praveen Chaudhari, Director of BNL, Mr. Michael Holland, Manager of the DOE Brookhaven Area Office, and Dr. Shirley Strum Kenny, Chairperson, Brookhaven Science Associates.

NSRL Ribbon Cutting Ceremony

Mr. John Schumacher, NASA Chief of Staff; Dr. Raymond Orbach, Director, DOE Office of Science; Congressman Timothy Bishop, 1st District of New York State; General Jefferson D. Howell, Jr., Director, Johnson Space Center; and Dr. Dennis Kovar, Associate Director, DOE Office of Nuclear Physics offered remarks outlining the history of the NSRL and their shared visions for its future as a radiobiology tool to enable the characterization of space radiation and its effects on living tissues and shielding materials.

General Jefferson D. Howell, Jr., Director, NASA Johnson Space Center; Mary Kicza, Associate Administrator, NASA Office of Biological and Physical Research; and Dr. Walter Schimmerling, NASA Space Radiation Program Scientist.

Development of a possible cooperative project was discussed by BNL's Dr. Derek Lowenstein and NASA's Dr. Walter Schimmerling in 1989; construction of the $34 million facility started in 1998 and was completed in 2003. Successful completion of the NSRL "ahead of schedule and slightly under budget" was attributed to the cooperation, patience, and perseverance of many scientists, engineers, business managers, budget analysts, and construction workers. Several of the speakers commented that the creation of the NSRL could serve as a model for other interagency partnerships.

Dr. Guy Fogleman, Director of the Bioastronautics Research Division, Office of Biological and Physical Research, NASA Headquarters, characterized the importance of the NSRL with the statement: "Scientists will use this facility as a research tool to protect today's crews on the International Space Station and to enable the next generation of explorers to safely go beyond Earth's protected neighborhood."

Later in the day, Dr. John Grunsfeld, astronaut, astronomer, astrophysicist, and newly appointed NASA Chief Scientist, discussed "Servicing the Hubble Space Telescope: Answering Fundamental Questions About Our World and Our Place in the Universe." He told a rapt audience of BNL employees, their families, friends, and guests how experiments performed in the NSRL will enable the simulation and study of the cosmic rays found in space, paving the way for NASA missions of discovery and exploration.

Dr. Francis Cucinotta, Project Chief Scientist, Space Radiation Health Project Office; Dr. James Slater, Loma Linda University Medical Center; and Mr. Andrew McNerney, Brookhaven National Lab.

Drs. Helen Lane, Steve Gonda, Chuck Sawin, NASA Johnson Space Center; Amy Kronenberg, Lawrence Berkely National Laboratory; and Greg Nelson, Loma Linda University Medical Center.

Update on the 3rd International Workshop on Space Radiation Research and 15th Annual NASA Space Radiation Health Investigators' Workshop

Scientists interested in attending the 3rd International Workshop on Space Radiation Research and 15th Annual NASA Space Radiation Health Investigators' Workshop May 16-20, 2004 are requested to indicate their intention to attend the Workshop by February 16, 2004. Click here to submit your response.

The Workshop will be held at Danfords on the Sound on the north shore of Long Island in Port Jefferson, New York. The Danfords' complex includes an inn, conference center, and marina.

Danfords on the Sound

Port Jefferson is located near the Department of Energy's Brookhaven National Laboratory and its newly commissioned NASA Space Radiation Laboratory (NSRL). One workshop session will be held at the Brookhaven National Laboratory and will include a tour of the NSRL. Following the Brookhaven session, Workshop participants will stop for lunch at a winery on Long Island's north shore. The first winery was established on Long Island only thirty years ago; today, there are more than two dozen wineries producing world-class wines from nearly 3,000 acres of vines.

Additional information about the Workshop will be posted to the workshop web site.

Funding Opportunities

New Research Solicitation: NRA 03-OBPR-07

Research proposals for NRA 03-OBPR-07, NASA-funded ground-based research in space radiation biology and space radiation shielding materials, were due January 9, 2004. Following the close of this solicitation, NASA will offer periodic funding opportunities to utilize the beams of high-energy heavy nuclei produced at the NASA Space Radiation Laboratory (NSRL) and the Alternating Gradient Synchrotron (AGS) at Brookhaven National Laboratory (BNL).

Proposals for NRA 03-OBPR-07 were solicited in the bioastronautics, fundamental biology, and physical sciences research areas. Specific questions and concerns in these areas follow. Questions in the bioastronautics area concern the application of mechanistic understanding to mammalian models to achieve significant reductions in the uncertainties in risk projections for cancer, degenerative tissue effects including damage to the CNS, and other health effects caused by space radiation or to develop effective biological countermeasures to these risks. Biological effects of importance include DNA damage processing, signal transduction, cell cycle controls, cellular differentiation, bystander effects, genomic instability, genetic sensitivity or resistance, and persistent oxidative damage. Solicited research will develop approaches to understand the effects of protons and heavy ions as modifiers of these processes. The use of such understanding to develop new transgenic mouse or tissue models improving our ability to extrapolate estimates of cancer and other risks to humans is of high priority. Finally, the development of methods for accurate, quantitative risk prediction is encouraged, both experimentally in terms of biological predictors of individual radiation risk and theoretically using appropriate models for quantitative individual risk assessments.

Proposals in the area of fundamental biology should be concerned with a basic understanding of the effects of the space radiation environment on fundamental biological processes that may include DNA structural and functional changes caused by radiation, such as mutations and DNA recombination and repair; basic metabolic controls important in biology and known to be modulated by radiation; the cell cycle, especially in relation to cellular repair mechanisms and programmed cell death; mechanisms of tissue and organ response to radiation including signal transduction; and "bystander" effects and genomic instability. The knowledge gained should have plausible links to studies directed at estimating risk to astronaut health and ameliorating negative health effects of space flight, as well as leading to quantitative predictions about the interaction of hypergravity or simulated microgravity on these mechanisms that can be subjected to experimental validation.

Physical sciences research focuses on the interaction of high energy charged (HZE) particles with matter and the design, fabrication, and testing of multifunctional radiation shielding materials. Novel research concepts that significantly accelerate NASA's development of an accurate modeling tool of the radiation transport phenomenon are solicited; NASA encourages researchers to utilize the facilities and capabilities of the Cross Section Measurements Consortium and the Radiation Transport Codes Consortium. Data and background information from the ongoing work of these groups is available at NASA's Space Radiation Shielding web site. Both the development of computational tools and shielding materials will be studied at the NASA Space Radiation Laboratory; basic and applied research in each of these areas is sought.

NASA has identified the following high-priority research topics for 2004:

- **Molecular Radiation Biology of Carcinogenesis** to improve estimates of cancer risks from space radiation using genetic- and molecular-based animal or tissue models and developing the knowledge needed to use such models to project risks in humans.
- **CNS Radiobiology** to address the understanding needed to estimate the risk to the central nervous system, especially the short-term and long-term degenerative risks from low doses (<0.3 Gy) of HZE particles and proton doses from solar particle events (0.1 to 3 Gy).
- **Models of Non-Cancer or Degenerative Tissue Risks** to address the identification of the mechanisms of these risks and the development of experimental models to estimate the risk from protons and HZE ions, including the basis for describing dose, dose-rate and latency dependencies.
- **Individual Susceptibility** to understand genetic or epigenetic factors that contribute to sensitivity or resistance to radiation and the development of molecular markers of cancer, CNS, or cataract risks that will allow NASA to project the individual's risk to space radiation.
- **Discovery of Biological Countermeasures** to address the development of the molecular understanding and identification of targets for risk assay development and intervention leading to the discovery of successful countermeasures for space radiation.
- **Cellular and Molecular Biology** to determine the nature of the lesions induced (both immediate and persistent), the mechanisms by which the lesions are formed, and the potential consequences of the induced damage to cellular processes. Of particular interest are studies of mammalian immune, neurological, gastrointestinal, bone, and muscle cells.
- **Novel Shielding and Multi-Functional Materials** to address the design, fabrication, and testing of materials that can be shown to approach or improve upon the performance of polyethylene as a shielding material.

NASA funding solicitation information is available at http://research.hq.nasa.gov/code_u/code_u.cfm.

Recipients of NSCORs, NRA 03-OBPR-02

Recipients of funding for NASA Specialized Centers of Research (NSCORs), in response to NRA 03-OBPR-02, have recently been announced. Three focused NSCOR research teams will address the biological consequences of space radiation:

1) Colorado State University - increased risk of leukemia
2) Lawrence Berkeley Laboratory - mechanisms of DNA damage and repair
3) Loma Linda University - the central nervous system

The NSCORs are similar to the NSCORTs (but without a training component) that have been funded in the past by NASA. The research will be conducted using ground-based irradiation facilities at the NASA Space Radiation Laboratory (NSRL) at Brookhaven National Laboratory (BNL) in Upton, New York.

Colorado State University

Colorado State University leads a team that includes investigators from the University of Texas M.D. Anderson Cancer Center and the Baylor College of Medicine who will investigate radiation risks that lead to cancer in astronauts and will identify genetic changes that are responsible for the development of radiation-induced leukemia.

In particular, the Colorado State team will study the development of acute myelogenous leukemia, or AML, which occurs in bone marrow stem cells and is one of the earliest and most common types of cancer that results following radiation exposure. The project will additionally focus on evaluating the impact of different radiation qualities and exposure times on the persistence, expansion and progression of cancer cells. Robert Ullrich, director of the Cancer Biology Group at Colorado State, is principal investigator of the project. Additional information about this NSCOR is available.

Lawrence Berkeley Laboratory

The Lawrence Berkeley Laboratory team will compare human mammary epithelial cells (HMEC) grown on tissue-culture plastic as traditional monolayers (2D) or in a physiological extracellular matrix as a multicellular (3D) culture to show differential expression of genes involved in DNA damage sensing and repair, in cell death and survival, and in cell cycle regulation. They will determine if the frequency of HZE (high energy) charged particle radiation induces genomic instability in both finite lifespan HMEC and immortal HMEC. Together, these surrogate functional HMEC endpoints will enable determination of the RBE of HZE neoplastic potential. These data will be integrated at two levels: by theoretical modeling of the physical events leading to DNA damage and by systems biology modeling of critical pathways. The intent of this project is to provide a comprehensive picture of HZE effects from the initial damage, to early cellular HMEC responses, to persistent functional precursors of carcinogenesis. NASA areas of interest that will be addressed include: mechanisms, nature, and frequency of DNA damaging events; mechanisms of DNA repair and misrepair, early signal transduction mechanisms; immediate and long-term, and reversible and irreversible gene expression changes; cellular remodeling and reorganization; potential mechanisms of tissue repair and matrix effects; induction and regulation of genomic instability; cellular and molecular mechanisms of charged particle-induced progression to a neoplastic phenotype. Ultimately, this work should help NASA develop a basic understanding of the mechanisms of HZE radiation damage and repair and their contributions to the neoplastic process.

Investigators include Director, Mary Helen Barcellos-Hoff; Associate Director, Amy Kronenberg; D. Sudar; M. R. Stampfer; B. Rydberg; D. Chen; F. Chen; P. Yaswen; J. Gray; Aloke Chatterjee; and B. Parvin. Their Advisory Committee includes M. J. Bissell, Chair; E. A. Blakely; T. F. Budinger; W. Dewey; Amato J. Giaccia; J. Miller; R. Sachs; B. Sutherland; and R. Ullrich.

Loma Linda University

Loma Linda researchers John Archambeau, Xiao-Wen Mao, André Obenaus, and Michael Pecaut with colleagues from six other institutions, led by principal investigator Gregory Nelson, have been awarded a five-year NASA Specialized Center of Research (NSCOR) program grant entitled "Progressive Alterations of Central Nervous System Structure and Function Are Caused by Charged Particle Radiation." The other institutions represented include: Stanford Research International, Inc. (Polly Chang), The Scripps Research Institute (Thomas Krucker), University of California at San Francisco (John Fike), Universty of California at Los Angeles (Igor Spigelman), University of North Carolina at Chapel Hill (Weili Lin), and Washington University in St. Louis (Sheng-Kwei Song). The work involves irradiation protocols using the Loma Linda University proton synchrotron for protons, the most common component of cosmic radiation, and the NASA Space Radiation Laboratory (NSRL) at the Brookhaven National Laboratory for high-energy iron ions, the most important heavy ions found in space.

The Loma Linda team will use mouse models to study long-term effects of radiation on the CNS to provide a foundation for understanding functional and structural changes that may arise following radiation exposure over a relatively long time scale; that is, the life spans of the animal subjects. Their strategy has three main goals. The first step is to quantitate radiation-induced loss of component cells in the hippocampus, a CNS region associated with learning and memory. Next, they plan to quantify the function(s) of CNS tissues. Finally, they will quantify molecular changes (biomarkers) that correlate with, or underlie, the cellular and system changes. The CNS NSCOR program project represents the first comprehensive investigation of the response of a mammalian brain structure to charged-particle radiation. The data set will establish a baseline for more detailed future investigations and will provide an initial scientific basis for NASA mission designers to estimate the health risks to astronauts embarked on long-duration space flights.

Radiation Protection Studies of International Space Station Extravehicular Activity Space Suits

A NASA Technical Paper NASA/TP-2003-212051 has been published on the radiation protection tests of Russian and American space suits, the Russian Space Agency (RSA) Orlan space suit and the NASA Extravehicular Mobility Unit (EMU), respectively.

Edited by Drs. Francis A. Cucinotta, Mark R. Shavers, Premkumar B. Saganti, and Jack Miller, the technical paper details the space suit testing that involved extensive collaborations between the NASA Johnson Space Center Extravehicular Activity Program Office, NASA Johnson Space Center Space Radiation Health Project Office, Russian Space Agency, Loma Linda University Proton Treatment Center, NASA Langley Research Center, Lawrence Berkeley National Laboratory, and the Brookhaven National Laboratory. Participants in the activity were scientists from the NASA Johnson Space Center, NASA JSC Space Radiation Health Project Office, NASA Langley Research Center, Loma Linda University, Lawrence Berkeley National Laboratory, and ERIL Research Corporation.

Computerized model of ISS EVA spacesuit developed by Radiation Shielding Design Team at NASA Langley Research Center

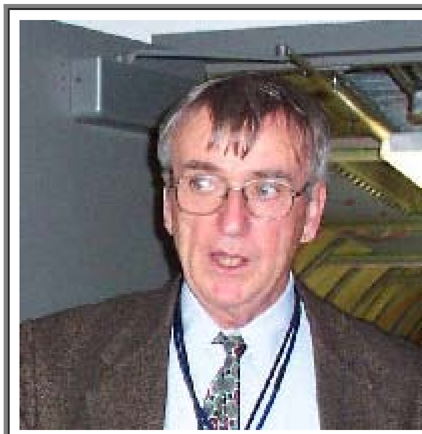
At the Loma Linda University Proton Treatment Center, the EMU and Orlan were irradiated with protons and electrons to simulate exposures during EVA operations; measurements were then taken. Additional tests with material layouts of the EMU suit sleeve were made at the Lawrence Berkeley National Laboratory 88-inch cyclotron and at the Brookhaven National Laboratory Alternating Gradient Synchrotron.

The primary objective of the measurements and analyses was to determine the radiation transmission properties of NASA's EMU and the Russian Orlan-M suit assemblies. Measurements focused on electrons and protons with energy sufficient to penetrate the EMU or Orlan suit to reach the skin, eye, blood-forming organs (BFO), stomach, lung, and brain. A second set of tests considered the transmission properties of relativistic iron and proton beams on a sample lay-up of the EMU. The tests utilized a human phantom to estimate organ doses and consider the effects of high-Z materials in the EMU or Orlan suit assembly and helmet, as well as dose contributions from target fragments including secondary neutrons. Data collected will be used to validate models that predict EVA organ doses in real-time to improve the accuracy of astronaut career exposure histories.

The specific test objectives were the following:

- To determine the minimal electron and proton penetration (threshold) energies at several locations on the EMU and Orlan-M suit assemblies.
- To use a human phantom to measure the dose, dose equivalent and LET spectra at the skin, eye, BFO, and other organs for several electron and proton energies.
- To measure transmission properties of a relativistic iron beam at tissue depths using a sample lay-up of the EMU.
- To compare the results of the newly taken measurements to those in the NASA Space Radiation Transport Code (HZETRN/BRYTRN) and computerized anatomical man (CAM) model.
- To develop data and knowledge for considering new approaches for design of EVA suits for LEO or Lunar/Mars missions.

SRHP Featured Investigator: Andrew McNerney

	**Andrew McNerney** Project Manager, NASA Space Radiation Laboratory Brookhaven National Laboratory

When young electrical engineer Andrew McNerney arrived at Brookhaven National Laboratory (BNL) in 1965, the Laboratory was just under twenty years old and in an exciting transitional phase. Its earliest facilities were being phased out to make way for newer technology.

Camp Upton to Brookhaven National Laboratory

The Laboratory, located in the middle of Long Island in Suffolk County, emerged from the framework of Camp Upton, which was itself carved from the pine forested Yaphank wilderness to serve as a training center for World War I army recruits. In September 1917, after an initial army of construction workers extended the Long Island Rail Road to receive construction supplies, removed trees, and built roads and buildings, the first army recruits arrived and helped finish the camp's construction. As the camp became operational, 40,000 men passed through it to learn the finer points of infantry combat, including tank, trench, and gas warfare; professional boxers taught hand-to-hand combat skills. A public auction of the equipment and facilities in August 1921 marked the end of its use as an army facility and heralded the return of the forest.

The forest grew until 1940 and the eve of World War II when Camp Upton was once more called into service as an army induction center. This time there was less clearing work to be done, and additions to the camp eventually enabled it to serve as a convalescent and rehabilitation center. As the war drew to a close, Camp Upton was officially declared surplus on June 30, 1945.

Rather than dismantle the camp once again, the government sought proposals to utilize the facilities and endow Camp Upton with a peacetime purpose. Thus the army camp where troops were trained for combat and rehabilitated afterwards became a research center to explore the peaceful uses of atomic energy.

Early Laboratory History

From the outset, the Laboratory was slated to provide unique facilities for high-energy physics research. In April 1948, the Atomic Energy Commission, predecessor to today's Department of Energy, approved a plan for a proton synchrotron to be built at Brookhaven. The new machine, called the Cosmotron, would accelerate protons to energies comparable to those of cosmic rays showering the Earth's outer atmosphere. After 14 years of service that included the discovery of the k0L meson and the first vector meson, the Cosmotron ceased operations in 1966 and was dismantled in 1969, a victim of its design limitations. To achieve a ten-fold increase in energies in an accelerator like the Cosmotron would have required 100 times more steel; therefore, Brookhaven physicists developed the strong focusing gradient concept now used in the construction of accelerators throughout the world. The Alternating Gradient Synchrotron, built on the innovative concept of the alternating gradient, has allowed scientists to accelerate protons to energies that would have been otherwise unachievable. The field gradients of the accelerator's 240 magnets are successively alternated inward and outward, permitting particles to be propelled and focused in both the horizontal and vertical plane at the same time. The AGS became the world's premiere accelerator when it reached its design energy of 33 billion electron volts (GeV) on July 29, 1960. Capable of accelerating 25 trillion protons with every pulse, and heavy ions such as gold and iron, the AGS is used by 850 users from 180 institutions from around the world annually.

The Brookhaven Graphite Research Reactor was the first reactor built in the U.S. after World War II. It was BNL's first large machine, and its purpose was to produce neutrons for scientific experimentation. Completed in 1949, the BGRR reached "criticality," or self-sustaining rate of nuclear chain reactions in August 1950. It served for 18 years before it was shutdown in 1968, its functions better served by the High Flux Beam Reactor beginning in 1966. The High Flux Beam Reactor achieved its operating power of 40 million watts in February 1966 and provided a reliable source for large quantities of neutrons and particles for nuclear physics, chemistry, condensed matter physics, and biology and medicine experiments. A leak of tritium from the facility's spent fuel pool caused the reactor's permanent decommissioning in 1999.

Thus, when Andrew McNerney arrived at the Laboratory in 1965, the Cosmotron and BGRR were in the process of being replaced by the Alternating Gradient Synchrotron and High Flux Beam Reactor, respectively.

The Building Years at BNL

A native of Brooklyn, New York, McNerney came to the Laboratory after earning B.S. and M.S. degrees in electrical engineering from the Polytechnic Institute of Brooklyn. At BNL he has served as chief engineer and/or project manager for operating facilities and projects for the past 20 years. During that time, he served as head of the RF Group and, for nine years, as Deputy Division head for the AGS. Most recently, from October 1999 until November 2003, he was Associate Department Chairman for Operations in the Collider-Accelerator Department. The primary mission of the Collider-Accelerator Department is to develop, improve, and operate the suite of particle/heavy ion accelerators used to carry out the program of accelerator-based experiments at the Laboratory. The machines under the purview of the Collider-Accelerator Department are the Relativistic Heavy Ion Collider (RHIC), Alternating Gradient Synchrotron (AGS), Alternating Gradient Booster, Tandem Van de Graaff Accelerator, Linear Accelerator (Linac), and the new NASA Space Radiation Laboratory (NSRL).

Shortly after McNerney arrived at the Laboratory, he worked on upgrading the radio frequency (rf) system for the existing 50-MeV proton linear accelerator (LINAC). Linacs can be designed to accelerate other charged particles, but in the Collider-Accelerator Department complex, the LINACs were designed for protons. After completing work on the 50-MeV LINAC, he worked on its replacement, the "new" 200-MeV Linac completed in 1971.

Another interesting project McNerney worked on involved cryogenic insulation and high voltage bushings for super-conducting power cables. This was a superconducting power transmission project that was brought to the demonstration stage at the Laboratory before funding was terminated. Some of the ideas and concepts pioneered during the project are used in the existing superconducting cable projects now used elsewhere.

He also worked on the Alternating Gradient Booster system, which was powered directly from the Long Island power grid without an intermediate motor-generator system as is the case for the AGS main magnet power supply system.

Recently, McNerney served as Project Manager for the NSRL, the collaboration project between the NASA Office of Biological and Physical Research and the Office of Science, U.S. Department of Energy to construct a high-energy, heavy-ion irradiation facility. The four-year, $34-million construction project will triple the number of NASA-sponsored radiobiology and shielding experiments that may be performed at BNL.

McNerney acknowledged that accelerator-collider projects like the NSRL require the collaboration of physicists and engineers: physicists to design the machine and engineers to interpret and construct their design. For the NSRL job, McNerney organized and coordinated the project, offered technical input, listened, got consensus, stayed on top of things, and made certain that the parts were constructed properly. He was responsible for assigning personnel and scheduling the construction, all of which were accomplished without incident because an experienced team of people worked on the project, which was completed on time and under budget.

Perhaps the greatest challenge in the construction of the NSRL came from the calendar. The NSRL was designed to include a beam tunnel that would receive heavy ions from the Lab's Booster Synchrotron. This meant that connection of the NSRL Beam Tunnel and the Booster had to be closely coordinated with the schedule of the Lab's huge Relativistic Heavy Ion Collider (RHIC) that also utilizes the Booster for beam acceleration. NSRL construction could not interfere with the experiments performed annually by the scores of investigators who use RHIC to study what the universe might have looked like immediately after its creation. The booster ring had to be penetrated and connected to the NSRL beam tunnel while RHIC was not in use. Fortunately, this construction was accomplished - within the tight timeframe -- during two summer shutdowns of the RHIC.

During the first summer shutdown, penetration into the Booster tunnel was accomplished. This effort included the construction of a "stub tunnel" with the appropriate radiation shielding. Completion of the stub tunnel enabled the building of the remainder of the NSRL beam tunnel to proceed independently and irrespective of the operating schedule of the RHIC.

During the second RHIC summer shutdown (in 2002), a new beam extraction system for injection into the NSRL beam line was constructed by modifying the Booster. This was the more demanding effort because it required insuring not only that the new system would work for NSRL, but also that the new system didn't affect the Booster's operation for RHIC.

The successful NSRL commissioning run (NSRL-0) from July 10-30, 2003 paved the way for the first experimental campaign. That campaign (NSRL-1) was successfully concluded in November 2003, delivering 284 hours of beam time (800 and 1000 MeV/nucleon iron, 1000 MeV/nucleon titanium and 290 MeV/nucleon carbon) to 24 experimental groups.

Fast Forward to the Future

After serving as Associate Chairman for Operations of the Collider-Accelerator Department since 1999, McNerney was named Interim Assistant Laboratory Director for Facilities and Operations, transitioning from being a "customer" on the Lab science side to leading a support team of 550 people. In this new position, he is responsible for Plant Engineering, Central Shops, Safeguards and Security, Emergency Services, and Staff Services.