MURR—The World's Most Powerful University Research Reactor

Blue skies, hills and valleys and all the other trappings of nature are not the kinds of details one would normally associate with a nuclear reactor, especially the most powerful and versatile university research reactor in the world. But it is in exactly this bucolic setting that the University of Missouri Research Reactor (MURR; Columbia, MO) has been housed for the past 32 years. Built on a former polo field, the Research Reactor Center is framed by a low, tree-covered, limestone ridge next to the Hinkson Creek Valley within the university's 85-acre Research Park.

Photo courtesy of Gary Ehrhardt, University of Missouri Research Reactor Center.

University of Missouri Research Reactor Center, Columbia, MO.

A flux-trap-type reactor with a high-intensity thermal and fast neutron flux—as great as 500 trillion neutrons per square centimeter per second—MURR has been at the forefront of several advances in the field of nuclear medicine, including the commercial production of technetium, the development of ^{153}Sm-EDTMP and research on a number of other radiopharmaceuticals. The high-flux neutron source is used in the research work of other departments within the university as well as by medical researchers, visiting universities, federal laboratories and industry.

"In the archeometry center we use the reactor to support the research of archaeologists from other major universities," said J. Charles McKibben, MURR associate director of operations. "We use neutron activation analysis to determine the trace elements in various materials for projects such as mesoamerican studies on obsidian." MURR has four program areas that provide opportunities for research and graduate education in neutron-related sciences. The Research Reactor Center has been at the leading edge of scientific progress in fields as diverse as biomedical research, nuclear engineering, archaeology, chemistry and materials science.

MURR was the brainchild of the late Huber O. Croft, dean emeritus of engineering. In the late 1950s, Croft, along with a group of four or five others, decided that the University of Missouri should build a research reactor and get involved in neutron-related sciences. Several universities had already built research reactors as part of President Eisenhower's "Atoms for Peace" movement, which advocated the research and development of nuclear materials for peacetime uses.

According to Chester Edwards, MURR facilities manager, "Dr. Elmer Ellis was the president of the university, and he was very much a visionary on what a land-grant institution and university could be. That collection of individuals, including Ellis, decided to lead the charge and bring a research reactor to this campus."

The $3.1 million construction costs were borne by the university and the state of Missouri. Groundbreaking took place in 1963. Ardath H. Emmons, supervisor at the Ford nuclear reactor and Phoenix Memorial Laboratory at the University of Michigan in Ann Arbor, was brought on as director for the new project. Emmons initially hired Internuclear of St. Louis to design the reactor itself and the Detroit architectural firm of Cornelius L.T. Gabler and Associates to design the laboratory building and all of the support equipment. "Cornelius Gabler

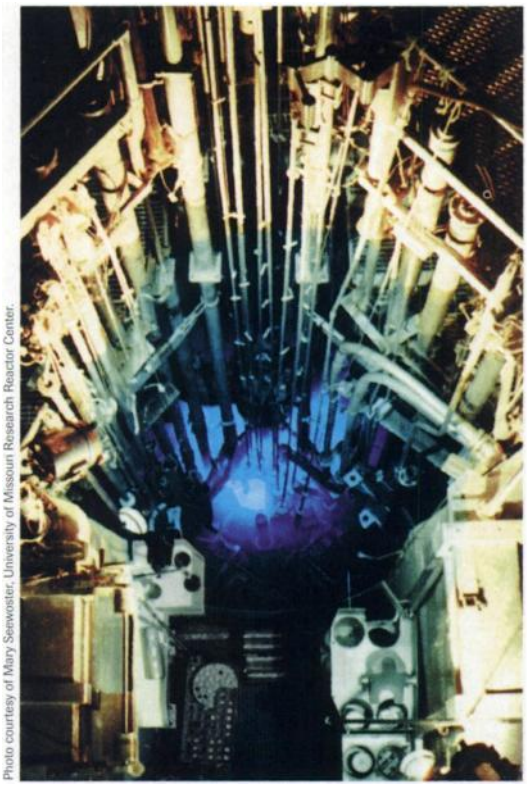

Photo courtesy of Mary Seewoster, University of Missouri Research Reactor Center.

University of Missouri Research Reactor core at 10 MW.

was a perfectionist who demanded a lot and brought a rather large support organization," said Edwards. "They built the Ford reactor and were also big in building infrastructure for the utility companies in the large cities." When Internuclear went out of business, General Electric (GE) was chosen as the subcontractor for the reactor. "GE was operating the GE Test Reactor (GETR) in Vallecito, CA. They modified Internuclear's original design concept and patterned it after GETR, which was a flux-trap-type, light-water reactor."

"Ellis kept his thumb on the pulse of the construction project," explained Edwards. "At one point they ran short of money. The university can't operate in the red, so what Dr. Ellis did was hock the university power plant, using it as collateral to borrow enough money to finish the project and then figured out a way to retire the debt. It was just one of the creative ways he used to get the project finished."

The plant was completed and began operating in October 1966 at 5 MW of power on a 20–30-hours-per-week, 5-day schedule. The plant originally had been designed to operate at 10 MW, but because of a funding shortage it was decided to postpone putting in the necessary reactor cooling equipment and instrumentation. "They chose to get the license for 5 MW, start operating and then, if the opportunity to operate at 10 MW presented itself, they'd come back, add the necessary equipment and apply for the license revisions," stated Edwards.

In the summer of 1967, MURR entered into a collaborative agreement with Mallinckrodt Nuclear of St. Louis to produce technetium commercially for the growing ^{99m}Tc market. The increase in revenue from the new relationship allowed MURR to increase staff and expand to three shifts on a 100-hours-week operating schedule. But the demand for ^{99m}Tc increased to the point where MURR could no longer meet Mallinckrodt's needs. In 1973 Mallinckrodt provided the start-up funding for the plant's upgrade to 10 MW, which MURR paid back in services.

The collaboration with Mallinckrodt ended in 1977. At that time, MURR began providing technetium for MetaPhysics, Inc., in upstate New York. "MetaPhysics came to us and said, 'We're not receiving enough material in one shipment a week.' They wanted to know if we'd be willing to go to two shipments a week on a 7-day operating schedule," said Edwards. In 1977, MURR began operating at its current 150-hours-per-week schedule.

According to Edwards, "We maintain a rigorous operating schedule. There've only been a couple of years when we haven't been running at 100% of our advertised operating schedule. Normally we run in the neighborhood of 102%–103%. One of the reasons we've been able to do that is because we've had a very dedicated group of support staff. We have people here with longevity who are very skilled, very competent and very dedicated."

Robert Brugger was hired as MURR's new director in 1974. Brugger began expanding MURR's research areas, developing MURR into a broad-based center capable of supporting several disciplines while still continuing to expand its income-earning potential. "Bob understood what high-quality research programming was about. He wanted MURR to be on par with any of the other major research institutions in the world," said Edwards.

One of the areas developed under Brugger's leadership was the radiopharmaceuticals division. "When I came here in 1979, there was a lot of interest in indium isotopes," said Dr. Gary Ehrhardt, senior research scientist and interim group leader. "There had been interest in some work done in Georgia on plastic microspheres loaded with ^{90}Y for treating various types of cancers, especially liver cancer. We came up with the idea of using microspheres made of silica-alumina, glass beads that had yttrium or phosphorous doped into them."

Interest in radiopharmaceuticals dated back to the reactor's early days. The late David E. Troutner, professor of chemistry at the university, had foreseen MURR's potential for use in developing radioisotopes and initiated its program in radiochemistry. "Troutner was a strong advocate for using reactor-produced beta emitters for radiotherapy. He concluded that two were particularly interesting. One was ^{186}Re and the other was ^{153}Sm, which eventually became the basis of Quadramet," noted Ehrhardt.

The development of ^{153}Sm was a collaborative university effort between the reactor, the chemistry department, the radiology department, the school of veterinary medicine, the medical school and Harry S. Truman Veteran's Hospital, with funding from Dow Chemical. "The chemistry was worked out initially by the chemistry department," Ehrhardt explained. "We did a trial of a whole

(Continued on page 26N)

MURR

(Continued from page 14N)

set of radiolanthanides trying to find the one with the best chemistry and the best physical properties. The initial patients were dogs at the vet school. Then, of course, it went to people—first here at Columbia, and then elsewhere in the country."

Samarium-153 was approved by the Food and Drug Administration for use as a palliative agent for metastatic bone disease in the U.S. in March 1997. MURR continues to supply the raw irradiated product for manufacture into that agent. The work with ^{153}Sm has led to work with other bone agents. MURR recently began assisting with clinical trials using ^{166}Ho as a marrow ablative agent for multiple myeloma.

Indeed, because of its pioneering work in the field, MURR is well placed to take advantage of the rapidly expanding area of therapeutic nuclear medicine. "We're suffering from funding problems like anyone else, and we don't have the infrastructure support that some government labs do, but we've always tried to work well within our means," commented Ehrhardt.

MURR continues to look forward as the new millenium approaches. One project in development is a $25 million, 81,500-square foot building addition that will provide additional research laboratories and office space. Current emphasis, however, is on the renewal of MURR's Nuclear Regulatory Commission operating license, which expires in November 2001. Stone and Webster Engineering Corporation (Boston, MA) was hired to develop the plan and budget that will allow MURR to upgrade its infrastructure. These improvements will allow MURR to continue making strides in nuclear medicine and biomedical research well into the next century.

—Jeffrey E. Williams

Radiopharmaceutical Measurement Assurance Program

(Continued from page 22N)

tory (of which the Radioactivity Group is a component) because of the commercial importance of nuclear medicine procedures, the customer service aspects of the program and the program's longevity and track record—over 20 years of data on costs and benefits that could be monitored.

According to the study's results, both patients and industry receive tremendous cost savings from the program. For example, without NIST standards, the accuracy of radiopharmaceuticals would decrease by 10%–15%, resulting in the need to redo about 1% of most diagnostic tests because of doses that are too low or test results that are unreadable. The use of NIST standards results in estimated savings of $45 million yearly for diagnostic procedures. According to the study, patients also see savings for therapeutic applications as well. Without NIST standards, 3% of all therapeutic procedures (of which about 1 million are performed annually at costs of $1500 to $2500 per procedure) would have to be repeated.

Manufacturers also reap economic benefits by not having to develop standards and resolve measurement discrepancies. "The radiopharmaceutical MAP is an excellent, cost-effective program," said Steingart, "particularly in view of the results we receive. It would be difficult for the radiopharmaceutical community to conduct a similar program, the special equipment is expensive and it would require cooperation from all the manufacturers regarding standards." According to the study, it would take 5–10 years to establish a privatized radiopharmaceutical standards entity if NIST abandoned the MAP program, at a cost of about $1.3 million per year during the transition phase.

—Eleanore Tapscot

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(Continued from page 3A)

reimburse for nuclear cardiology, inflammation imaging and SPECT imaging in general. We are currently reliving those experiences with PET imaging, cerebral perfusion imaging, fusion imaging and the diagnostic and therapeutic use of radiolabeled antibodies and peptides. How many efforts by academic centers and industry have been aborted because of the lack of financial support and subsequent fear of the effect of failure?

Medicine and our specialty, nuclear medicine, frequently overcame past adversities and achieved its current successes. We must continue to believe in, and subsequently prove, the efficacy of our newly developed procedures and commit our personal and professional resources to achieve new successes despite the lack of vision of others who fail to see the value in the quality of health care provided by these procedures.

Stanley J. Goldsmith
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