

## CONTACT INFORMATION

The NRL's professional staff are available to assist experimenters, educators, and students.

□ **David E. Moncton, Director.** Professor Moncton is responsible for overseeing operation of the Nuclear Reactor Laboratory (NRL). He is a condensed matter physicist with extensive experience in research as well as in the construction and management of large DOE user facilities. His research includes x-ray and neutron scattering studies of phase transitions and novel states of condensed matter. (617) 253-8333

□ **Thomas H. Newton, Director of Reactor Operations and Associate Director for Reactor Engineering.** Dr. Newton oversees and is responsible for all matters concerning operation of the NRL's 6 MW research reactor (MITR-II). His group is comprised of reactor operators that have been licensed by the NRC, student trainees, and experienced reactor engineers and technicians. In addition, he is also responsible for all aspects of management of fuel in the reactor, and engineering support of experiments and reactor upgrades. (617) 253-4211

□ **Lin-Wen Hu, Associate Director of Research Development and Utilization.** Dr. Hu is responsible for all utilization activities at the NRL including overseeing the design, implementation, and safety of experimental facilities used by MIT and outside researchers. Dr. Hu's expertise is in the areas of advanced nuclear fuels and materials, thermal hydraulics, and reactor safety analyses. (617) 258-5860

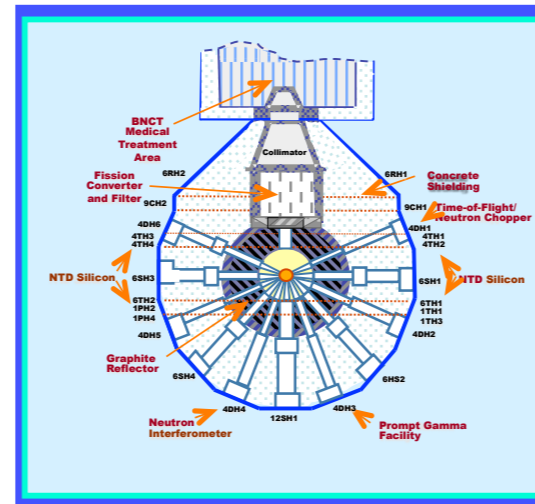
□ **Edward S. Lau, Assistant Director of Reactor Operations.** Mr. Lau is responsible for overseeing that operational procedures are in compliance, NRC inspections, and security. (617) 253-4211

□ **John A. Bernard, Senior Advisor.** Dr. Bernard's background is in chemical and nuclear engineering. He is responsible for regulatory issues that affect the NRL. His expertise is in the areas of closed-loop digital control of nuclear reactors; use of nuclear energy for the exploration of space; and artificial intelligence applications to nuclear reactors. He is a certified health physicist. (617)253-4202

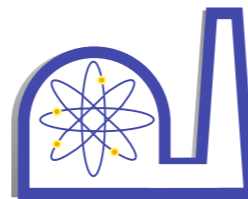
□ **Mary E. Young, Administrative Officer.** She is responsible for all financial and personnel matters related to the NRL as well as grant coordination and administration. (617) 253-0008

□ **William B. McCarthy, Deputy Director, NRL Environment, Health and Safety.** Dr. McCarthy and his group are responsible for all matters concerning radiation protection at the Nuclear Reactor Laboratory. (617)353-0346

For more information, call (617)253-4211 or visit <http://web.mit.edu/nrl/www/index.html>



## Massachusetts Institute of Technology Nuclear Reactor Laboratory (MIT-NRL)



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## MISSION AND GOALS

The MIT Nuclear Reactor Laboratory (NRL), which has served the university and surrounding community for 52 years, is an interdepartmental center that operates a 6 MW research reactor (MITR-II) in support of MIT's educational and research mission. No electricity is produced.

The MITR-II is the second largest university research reactor in the United States and the only one located at a major research university.

Its mission is to provide faculty and students from MIT, researchers from the national scientific and engineering communities, as well as local area universities and hospitals with both a state-of-the-art nuclear facility and the infrastructure to enable its use for important research and other societal objectives. Highest priority is placed on operating in a highly professional manner which is safe to the public, to the researchers and employees, and to the environment.

In addition to the NRL's role as a major center for neutron research, it is committed to educating the general public by promoting education and training in nuclear science and technology.

The MITR-II is the second of two research reactors that have been operated by MIT. The original one, the MITR-I, first achieved criticality in 1958. In 1974, that reactor was shut down in order to allow conversion to the MITR-II which offered a higher neutron flux level.

## DESCRIPTION OF THE MITR-II

The MITR-II is a light-water cooled and moderated nuclear reactor that utilizes flat plate-type finned, aluminum clad fuel elements. The MITR-II, which currently operates at 6 MW, is located in the center of a gas-tight cylindrical steel building that is equipped with a controlled pressure relief system. Access to the containment building is through either a personnel or a truck airlock. The reactor core consists of rhomboid-shaped elements arranged in a hexagonal pattern. There are generally 24 elements and 3 in-core irradiation positions. The core is located at the center of a light-water tank which is in turn surrounded by a heavy-water tank, a graphite reflector, a thermal shield, and finally a biological



shield. Additional safety is achieved since the light-water coolant, the heavy water, and the shield regions are all separately cooled. The MIT reactor runs at atmospheric pressure and 55 °C (the temperature of hot bath water). The nuclear reaction is controlled by inserting neutron absorbing blades. To provide an alternative shutdown mechanism, the heavy water can be dumped to a holding tank eliminating the reflected neutron flux necessary to sustain a reaction. Furthermore, when either the cooling water or the fuel temperature rises, the reaction rate is decreased, thereby providing passive safety. The maximum thermal neutron flux available to experimenters is  $6 \times 10^{13}$  neutrons/cm<sup>2</sup>sec. MITR-II flux levels while operating at 6 MW are as follows:

MITR Neutron Flux Levels @ 6 MW*	
Facility	Neutron Flux (n/cm <sup>2</sup> -s)/ Gamma Dose Rate
In-Core	Thermal: $3.6 \times 10^{13}$ Fast: Up to $1.2 \times 10^{14}$ Gamma Dose Rate: $10^{16}$ - $10^8$ Gy/h
Beam Ports	Thermal: $1 \times 10^{10}$ - $1 \times 10^{13}$
Pneumatic Tubes	Thermal: $9 \times 10^{12}$ to $6 \times 10^{13}$
Basement Medical Room	Thermal: Up to $1 \times 10^{10}$
Fission Converter Beam	Epithermal: $\sim 5 \times 10^9$
Gamma Irradiation Facility	Gamma Dose Rate: Up to 120 Gy/h
*At source	

## WHAT DOES THIS MEAN IN LAYPERSON TERMS?

While the MITR-II research reactor does not produce electricity, its mission is to produce neutrons that are used in various cutting-edge scientific and engineering studies. Its power level is 6 MW, compared to 3000 MW for a large electric power reactor. Because of its low power and small size, and its passive safety design features, it does not present a significant safety concern.

## EXPERIMENTAL FACILITIES

The MITR-II is the major experimental facility at the NRL. It is available 24/7 except for scheduled outages for reactor upgrades and maintenance. The MITR-II supports a broad research program that encompasses most aspects of neutron science and engineering, including materials testing and evaluations, fission engineering, nuclear medicine, neutron scattering, neutron activation analysis, and teaching. Current research and service areas supported by the MITR-II include:

- Infrastructure to support the US initiative for designing and building the next generation of nuclear reactors as a means of reducing the country's reliance on fossil fuels.
- Advanced materials and fuel research.
- Trace element analysis, isotope production, and irradiation services.
- Neutron transmutation doping of silicon.
- Neutron scattering.

Available facilities and capabilities include:

### Beam Ports

Numerous beam ports penetrate the reactor's shield, graphite reflector, and heavy-water reflector. These provide a high-quality neutron beams for neutron scattering, prompt-gamma analysis, neutron physics, and other uses.

### In-Core Sample Assemblies

The MITR-II offers a unique technical capability to design and implement in-core loops that replicate pressurized or boiling-water reactor conditions to study the behavior of advanced materials, and to perform scoping studies of advanced nuclear fuel. There are twenty-seven fuel element positions. Depending on fuel burn-up, generally 24 elements are required to achieve criticality. The other 3 positions can be occupied by in-core experimental assemblies, or loops, to carry out experiments that replicate conditions in pressurized or boiling-water reactors, or expected in new designs.

### Time-of-Flight Experimental Facility

The web-enabled time-of-flight experimental facility is available to students and can be operated locally or over the internet to measure neutron energy distributions and absorption.

### Neutron Scattering Experimental Facility

Neutron scattering and spectroscopy are among the preeminent tools for studying the structure and dynamics of matter at the atomic and molecular scales. The NRL's neutron scattering instruments include:

➤ A triple-axis diffractometer that is equipped with focusing PG monochromator, PG analyzer, He<sup>3</sup> monitor and detector and standard collimators, slits and PG filters. This instrument is suitable for elastic neutron scattering experiments on characterizing novel materials and is an important tool for students training in neutron scattering.

➤ A neutron optics test station has polychromatic neutron beam for tests of neutron detectors, mirrors, and other neutron instrumentation components.

### Medical Irradiation Rooms

Two facilities are available. One is located in the basement and uses a neutron beam from the reactor core. The other, located on the reactor floor, utilizes a beam produced by a fission converter driven by neutrons from the core. The epithermal beam from the fission converter is the highest intensity beam available in the world. The basement facility's beam may be either thermal or epithermal depending on the filters that are used. Both facilities are available to support research in the medical uses of neutrons in cancer therapy.

### Nanofluids Laboratory

The nanofluids laboratory experimental facilities and associated instrumentation are part of the thermal hydraulics laboratory supported jointly by the Nuclear Science and Engineering Department (NSE) and the NRL. These facilities can be used for research projects in general heat transfer and two-phase flow research as well as teaching at both undergraduate and graduate levels.

### Neutron Activation Analysis Facility

The MITR neutron activation (NAA) facility is currently equipped for both prompt and delayed gamma neutron activation analysis. The NRL makes its NAA facilities and expertise available to industry, other universities, private and governmental laboratories, and hospitals. Both research and service-oriented collaborations are underway with MIT research laboratories as well as with other educational and research institutions.

### Automatic Sample Transfer

The MITR is equipped with pneumatically-operated horizontal tubes that allow samples to be exposed to various neutron fluxes. These facilities are normally used to support the neutron activation analysis of environmental samples such as air pollutants.

### Graphite Reflector

Vertical irradiation thimbles penetrate the graphite reflector which surrounds the MITR core. These thimbles are normally used for the activation of specimens that require a uniform, thermal flux.

## EDUCATIONAL OPPORTUNITIES

NRL supports a strong educational program including:

➤ Outreach to the educational community as well as the general public that encourages understanding of nuclear energy and its applications by providing tours and lectures.

➤ Supporting MIT's educational missions by providing: Independent Activities Period (IAP) lectures; hosting Undergraduate Research Opportunities Program (UROP) students; and offering lab courses for professionals, undergraduates, and advanced secondary school students.

➤ Web-enabled time-of-flight experimental facility.

➤ NRL staff that assist in research projects, theses, sample irradiations, neutron activation analyses (NAA), experiments, hands-on training, and other educational activities.

## REACTOR OPERATOR TRAINING

The NRL offers Reactor Operator's Training to several MIT students each year. These students undergo several months of training and



studying. They are then eligible to take a two-day exam administered by the U.S. Nuclear Regulatory Commission in order to obtain their Reactor Operator's License. After successfully passing the course and NRC exam, these students are then offered part-time positions as Reactor Operators. This program is exceedingly popular among students. In addition, all NRL staff working directly with the reactor are required to complete this training.

## RESEARCH

The NRL has supported and contributed to many research projects through the years, such as closed-loop digital control of spacecraft and terrestrial reactors; boron neutron capture therapy for the treatment of cancer; material studies for the next generation of reactors; neutron activation analysis used for the study of autism; and the investigation of nanofluids for nuclear applications.

The NRL has one of the strongest materials and in-core loop programs in the country that supports research in the areas of advanced nuclear fuel and materials which are necessary for both existing and advanced power reactors. There is rekindled interest on the part of the US Department of Energy (DOE) and the national nuclear industry in building the next-generation of nuclear power systems, many using novel materials and advanced forms of fuel. Therefore, facilities such as the MITR-II are in high demand to test material and fuel behavior in a variety of radiation environments.

The MITR-II is arguably the best-suited university reactor for carrying out such studies because of its relatively high-power density (similar to a light-water reactor), the capability to control chemistry and thermal conditions to reflect prototypic conditions, its easy-access geometric configuration, and space for up to three independent irradiation tests.

## PARTNERSHIP WITH ATR-NSUF

The MITR Research Reactor is a partner facility of the DOE-Idaho National Laboratory's Advanced Test Reactor National Scientific User Facility (ATR-NSUF) which is charged with performing fuel and advanced materials irradiation experiments crucial to future-generation reactors. This collaboration is designed to increase user access to national reactor irradiations and testing capabilities. The NSUF test space at both reactors is made available at no cost to external users whose projects are selected via a peer review process. The MITR-II offers a portion of its test capability to NSUF experimenters.

## REACTOR SAFETY

Safe operation of the 6 MW MITR-II is the highest priority for each member of the NRL's highly-trained staff. Reactor safety is ensured by an array of engineered systems and passive designs. Oversight is provided by the U.S. Nuclear Regulatory Commission, MIT's EHS Radiation Protection Office, and the MIT Reactor Safeguards Committee.