

THE NEUTRON UTILIZATION AND PROMOTION PROGRAM OF TRR-II RESEARCH REACTOR PROJECT IN TAIWAN

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Abstract

The objective of the Taiwan Research Reactor System Improvement and Utilization Promotion Project is to reconstruct the old Taiwan Research Reactor (TRR), which was operated by the Institute of Nuclear Energy Research (INER) between 1973 and 1988, into a multi-purpose medium flux research reactor (TRR-II). The project started in 1998, and the new reactor is scheduled to have its first critical in June of 2006. The estimated maximum unperturbed thermal neutron flux ($E < 0.625$ eV) is approximately 2.7×10^{14} n/cm²sec, and it is about one order of magnitude higher than other operating research reactors in Taiwan. The new reactor will equip with secondary neutron sources to provide neutrons with different energies, which will be an essential tool for advanced material researches in Taiwan.

One of the major tasks of TRR-II project is to promote domestic utilization of neutrons generated at TRR-II. The traditional uses of neutrons in fuel/material research, trace element analysis, and isotope production has been carried out at INER for many years. On the other hand, it is obvious that promotions of neutron spectrometric technique will be a major challenge for the project team. The limited neutron flux from operating research reactors had discouraged domestic users in developing neutron spectrometric technique for many years, and only few researchers in Taiwan are experienced in using spectrometers. It is important for the project team to encourage domestic researchers to use neutron spectrometers provided by TRR-II as a tool for their future researches in various fields.

This paper describes the current status of TRR-II neutron utilization and promotion program. The current status and future plans for important issues such as staff recruiting, personnel training, international collaboration, and promotion strategy will be described.

1. Introduction

The Taiwan Research Reactor System Improvement and Utilization Promotion Project is to reconstruct the old Taiwan Research Reactor (TRR) into a new multi-purpose medium flux research reactor (TRR-II). The major tasks of this project includes removing the old TRR reactor vessel from its original location, constructing a new open pool research reactor, installing various experimental facilities, and encouraging domestic researchers to use this neutron source in Taiwan [1]. The project was approved by the government in October 1998, and the new reactor is scheduled to be first critical in June of 2006.

The TRR-II project is supervised by three committees with different functions. The Steering Committee (SC) is responsible for determining the guidelines and reviewing the overall progress of the project. The Technical Review Committee (TRC) reviews the progresses and provides suggestions on dismantling and reconstruction of the reactor, and designs and installations of experimental facilities. The Neutron Application Review Committee (NARC) is organized by domestic users and representatives from academic institutes to provide guidelines for neutron researches in various areas. The organizational chart of the TRR-II is shown in Figure 1. Four divisions including dismantling, reconstruction, experimental facilities and neutron application are included, and the neutron application division (NAD) is responsible for the neutron utilization and promotion program. The major tasks of

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the NAD include construction of two cold neutron guides and four spectrometers, personnel training, and promotion of neutron applications for TRR-II experimental facilities. The division meets with NARC members more than twice a year, and a newly formed independent center (tentative name “Neutron Application Research Center”) might replace the functions of NARC in the future.

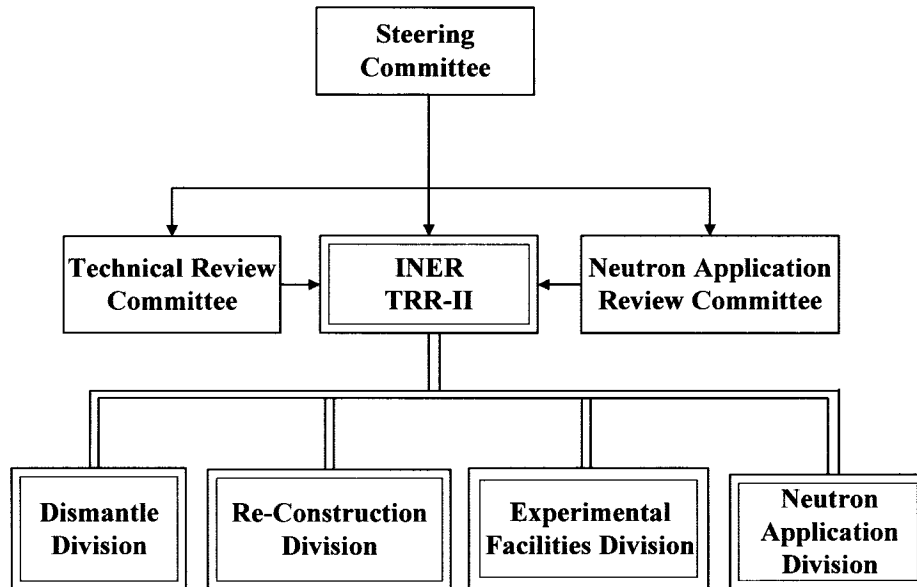


Figure 1. TRR-II Organizational Chart

2. Experimental Facilities

The NAD promotes neutron applications for experimental facilities to be installed at TRR-II, which are listed in Table 1. The traditional use of neutrons in fuel/material research, trace element analysis, and isotope production has been carried out at INER for many years. On the other hand, it is obvious that promotions of neutron spectrometric technique will be a major challenge for the project team.

Table 1. TRR-II Experimental Facilities

Item	Facilities
Cold Neutron Source (CNS)	One Liquid Hydrogen-Cooled CNS Facility with Helium Refrigerator
Neutron Beam and Guide	Two Cold Neutron Guides
	Six Neutron Beam Tubes
Neutron Spectrometer	One 40 m Small-Angle Neutron Scattering Instrument (SANS)
	One High-Resolution Powder Diffractometer (HRPD)
	One Vertical Focusing Reflectometer (RF)
Fuel/Material Test Facility	One Triple-Axis Spectrometer (TAS)
	One Pool Side Hot Cell
	One Material Test Facility
	One Neutron Radiography Facility
Isotope Production Facility	Five In-Core Irradiation Positions
	Three Vertical Irradiation Positions in Heavy Water Tank
	One Pneumatic Tube
Neutron Activation Analysis Facility	One Hydraulic Tube
	Two Pneumatic Tubes
Neutron Transmutation Doping Facility	One $\phi=180\text{mm}$ Vertical Tube with Loading and Driving Mechanisms
	One $\phi=180\text{mm}$ Spare Irradiation Position in Heavy Water Tank
Others	Spaces Reserved for Hot Neutron Source, Boron Neutron Capture Therapy

The TRR-II reactor core is a 5× 6 grid box loaded with 21 low enrichment standard fuels (<20% enrichment U_3Si_2-Al) surrounded by a D_2O tank two meters in diameter. The reactor will have five thermal neutron beam tubes around its D_2O tank in the reactor building, and a liquid hydrogen-cooled cold neutron source (CNS) with two extended cold neutron beam tubes. The first floor of the reactor building has the width of 10 meter around biological shielding for installing cold and thermal neutron spectrometers, and a new guide hall with the dimension of 62m (L)× 50m (W)× 17m (H) next to the reactor building will be built to install spectrometers using cold neutrons. Table 2 and Figure 2 shows the general layout of neutron spectrometers in the two buildings and their potential applications. The spaces of these two buildings are enough for 16 spectrometers. However, after consulting with TRC and NARC, only four spectrometers (as shown in Table 1) will be built within the scope of TRR-II project due to limited budget and manpower. Both SANS and RF will be installed at the guide hall using cold neutrons, and HRPD and TAS will be installed at the reactor building using thermal neutrons. These neutron scattering facilities will increase the research capabilities in material science, biology and condensed matter physics in Taiwan.

Table 2. TRR-II Neutron Spectrometer Arrangements and Applications

	INSTRUMENT	LOCATION	Applications
Thermal Neutron (25meV)	High Resolution Powder Diffractometer (HRPD)	BT2*	Crystallographic Analysis, Magnetic Structures, High Tc Superconductors and Related Material
		BT5	Polarized Neutron Beam for Phonon and Magnon researches
	Triple Axis Spectrometer (TAS)	BT3 *	Magnetic Excitations, Molecular Spectroscopy, Lattice Vibration Studies, Dynamics of Polymer
	Residual Stress Diffractometer (RSD)	BT4	Depth Profiling of Residual Stress in Large Components
Cold (~meV)	Small Angle Scattering Instrument (SANS)	NG2A*	Microstructure Measurement, Polymer and New Material Structure Studies, Membrane Structure
		NG2B	
	Reflectometer (RF)	NG1B*	Magnetic Multilayers, Artificial Membranes, Semiconductor Surfaces, Interfacial Science
	Backscattering Spectrometer (BS)	CG1B	Rotational Tunneling, Molecular Reorientations, Diffusions, Dynamics of Viscous Liquids
	Time of Flight Spectrometer (TOF)	CG4A	Dynamic in Condensed Matter, Macromolecular Systems
	Triple Axis Spectrometer (TAS)	CG3	Superlattice Magnons, Antiferromagnetic Reorientation, Phase Transition Studies
	Neutron Spin-Echo Spectrometer (NSE)	CG3	Polymer, Biological Model Systems, Proteins
	Prompt Gamma Activation Analysis (PGAA)	CG3	Trace Element Analysis, Certify Reference Material
	Neutron Interferometer (NI)	CG4B	Magnetic/Nuclear/Structure Properties of Material, Quantum Physics Researches
	Neutron Physics Station (NPS)	CG1A	Cold Neutron Physical Properties and Basic Researches, Cold Neutron Trapping
	Spare Cold Neutron Beam	BT1	Subsurface Impurities and Coatings

* Built Within the Scope of TRR-II Project

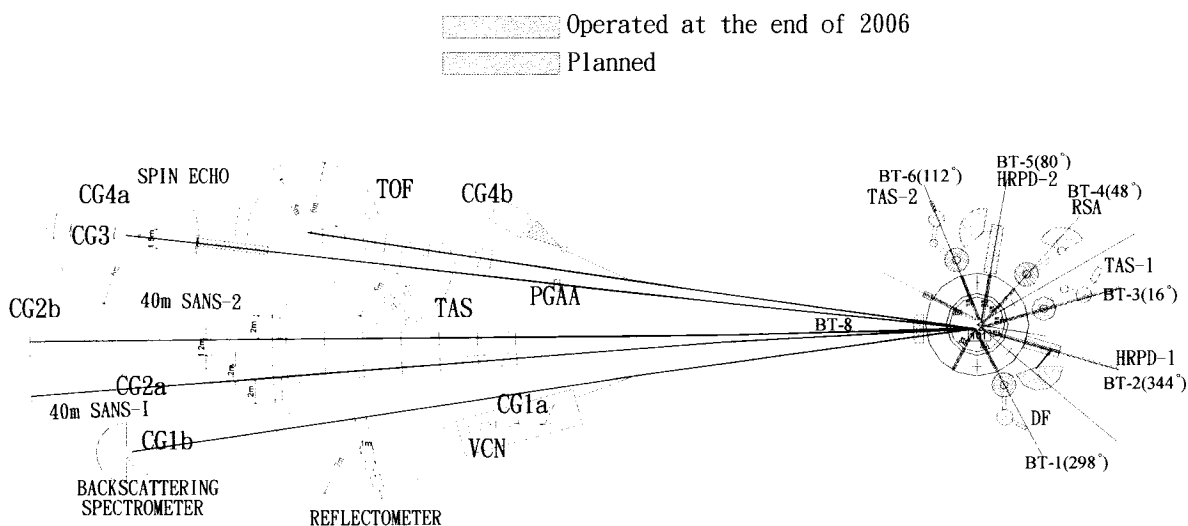


Figure 2. TRR-II Neutron Spectrometer Arrangements in Reactor and Guide Halls

3. Neutron Utilization and Promotion Program

The neutron utilization and promotion program (NUPP) of TRR-II project includes general applications of neutrons at INER, personnel recruiting and training program, establishment of an independent center (Neutron Application Research Center) for neutron scattering applications, and set up international collaboration channels [2]. The short-term goal of NUPP is to encourage domestic users to form informal Participating Research Teams (PRT) , and the long-term goal is to play an active role in the international neutron research societies. TRR-II neutron application division is responsible for the NUPP program, with consultancies from NARC members.

General Applications of Neutrons at INER

The traditional use of neutrons on fuel/material research, trace element analysis, and isotope production had been conducted by different divisions at INER for more than 20 years, and scientists and engineers from these divisions have involved in designing the related experimental facilities. However, it is important to encourage more domestic users and to find possible financial supports to maintain continuous operations of these facilities. For the neutron transmutation doping, it is especially important to identify the semiconductor companies and provide services to them. The NAD is about to publish a report that covers the current and future markets for these applications. This report also describes the rationals for the scope of each experimental facility.

Personnel Recruiting and Training Program

The limited neutron flux from existing research reactors in Taiwan had discouraged domestic users in developing neutron spectrometric technique, and only few researchers are experienced in using spectrometers. However, it is obvious that neutron scattering is an important tool for structural and dynamic studies of the material sciences, chemistry, and biology [3]. INER does not have much experiences on neutron scattering , especially in construction of neutron guide and spectrometers. It is critical to recruit new members in order to satisfactorily complete the construction of two neutron guides and four spectrometers.

INER is a state-owned institute, and strict regulations are applied to recruiting processes. TRR-II project had submitted a proposal to the Executive Yuan to recruit ten new members, which was officially approved last year. Four young scientists will be recruited to join the team this year. Four other new members are expected to join the project team in the year 2002, and two more in 2003. In addition, two military-service scientists with doctoral degrees from domestic universities are also expected to join the team this year. These new scientists, together with INER's staffs, will be responsible for constructions of neutron guides and spectrometers in the next five years. TRR-II project also had initiated a program to subsidize qualified domestic doctoral students and post-doctors to do researches and to conduct neutron scattering experiments at foreign facilities. Seven students are awarded with monthly payments and five students are subsidized for the expenses in conducting experiments this year. These students will become candidates as project staffs, and they will also become the potential users for the new spectrometers.

One of the major challenges of NAD is to train the scientists and engineers who are responsible for constructions of neutron guides and spectrometers. The strategies for personnel training include: inviting foreign experts for consulting on neutron guides and spectrometer designs, setting up collaborative programs with foreign neutron research institutes, and dispatching TRR-II staffs to foreign facilities for on-site trainings. There were more than seven experts from the National Institute of Standards and Technology (NIST), Institut Laue-Langevin (ILL), Paul Scherrer Institut (PSI), and Kyoto University Research Reactor Institute (KURRI) had visited the project last year, and it is expected to have comparable number of experts to visit the project this year. For the collaborative programs with foreign institutes, TRR-II has co-signed the agreement with the NIST for technical supports and personnel training in the next five years (2001~2005) . The TRR-II project team will dispatch three qualified persons to NIST for training on neutron-scattering-related areas this year, and further cooperation channels with other neutron research centers are under discussions. Two TRR-II staffs had visited the FRM-II facility of Germany to observe the installation of neutron guides and spectrometers between October and November last year, and more staffs are expected to be dispatched to ILL and FRM-II in the year of 2002.

Neutron Application Research Center

As mentioned earlier, neutron scattering is an important tool for structural and dynamic studies of the material sciences, chemistry, and biology. However, only few researchers in Taiwan are experienced in using neutron spectrometers due to the limited neutron flux provided by operating research reactors in Taiwan. The NAD had proposed to the SC to organize an independent center (tentative name Neutron Application Research Center, NAPRC), which will be dedicated to developing neutron scattering instruments and conducting neutron scattering researches in Taiwan. The NAPRC is expected to coordinate resources from INER, domestic universities and academic institutes, and focuses on neutron scattering related applications. The SC agreed to form a NAPRC planning group to conduct the feasibility studies, and two meetings were held on January 19 and March 27, 2001 to discuss the missions and organizations of the new center. The NAPRC planning group has 13 members selected from INER, domestic and international universities, and academic institutes in Taiwan. Figure 3 shows the NAPRC organization suggested by the planning group with two options on the governing authority (National Science Council or Atomic Energy Council). These recommendations will be discussed at the next SC meeting in the coming June.

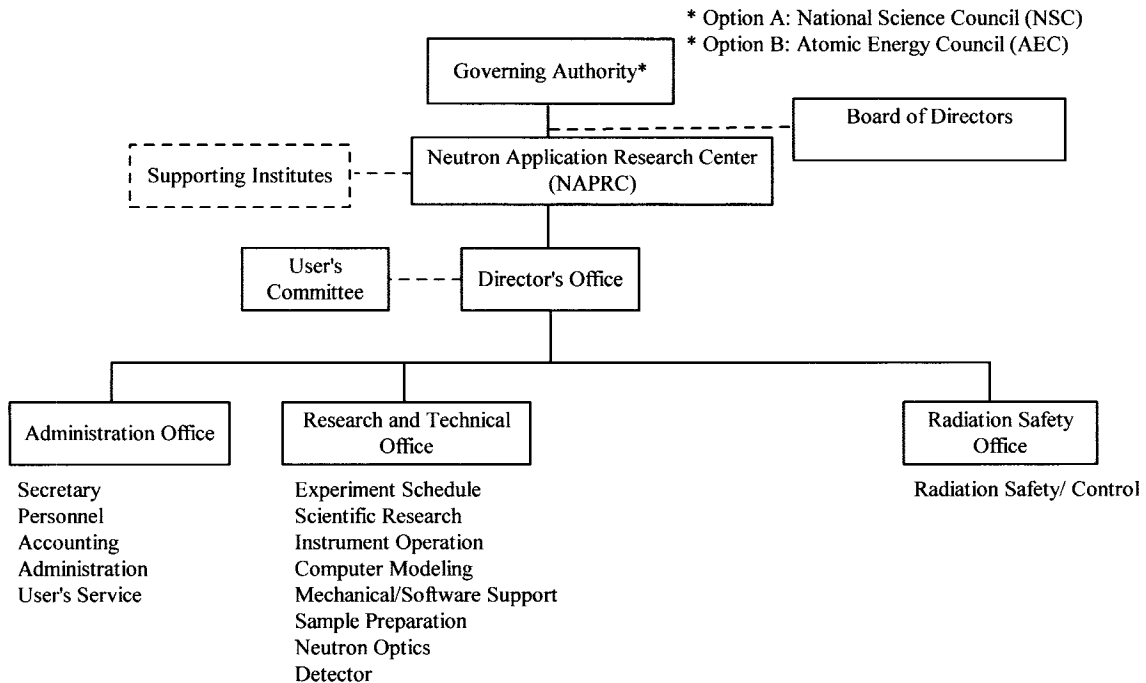


Figure 3 Neutron Application Research Center Organization Suggested by NAPRC Planning Group

International Collaboration

One of the major goals of NUPP is to set up connections with international neutron research societies. The neutron applications on fuel/material research, trace element analysis, and isotope production had been carried out by INER with collaborations with other international organizations for many years. However, INER has no experiences on neutron scattering, and collaborations with other neutron research centers are critical for the successfulness of neutron scattering applications in Taiwan. TRR-II has co-signed the collaboration agreement with the NIST for technical supports and personnel training. The major efforts this year will be focused on collaborations with European and Asian neutron research centers. The project team has reached a preliminary consensus on dispatching INER's staffs to join the neutron scattering researches and supporting teams at ILL and FRM-II. However, official channels have not been set up at this moment. This year, four INER members attended the Asian region symposium of neutron beam applications held in Japan, which could be critical for the future cooperations with Asian countries.

4. Conclusion

The neutron utilization and promotion program of TRR-II project is critical to the success of neutron applications in Taiwan. The project team is about to publish a report to cover the current and future market prediction on traditional neutron applications at INER. This report provides information on costs/benefits of TRR-II experimental facilities and their future applications. The project invited more than seven experts from NIST, ILL, PSI, and KURRI to discuss with INER's staffs on neutron guide and spectrometer designs last year, and the progresses of these two systems are plausible at this stage. TRR-II is expecting to have a comparable number of experts from international neutron research centers to visit the project team this year. With ten new members recruited in the next three years, we hope the designs and constructions of neutron guides and spectrometers can be satisfactorily done.

A planning group with 13 members from INER, domestic and international universities, and academic institutes in Taiwan has been selected to organize an independent center (NAPRC) for promotions of neutron scattering related applications. The planning group has made suggestions on organization structure of NAPRC, which will be discussed and hopefully finalized at the coming SC meeting on June 15, 2001.

TRR-II has co-signed the collaboration agreement with the NIST for technical supports and personnel training, and the major efforts will be focused on collaborations with European and Asian neutron research centers this year. In addition, TRR-II will co-sponsor a symposium on x-ray and neutron scattering at the end of this year. With all these promotion activities, we hope we are marching on the right way toward the successful operation of experimental facilities at TRR-II.

5. References

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