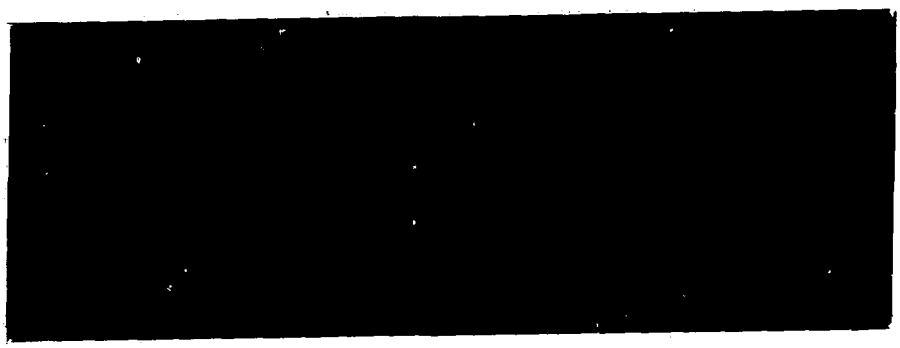

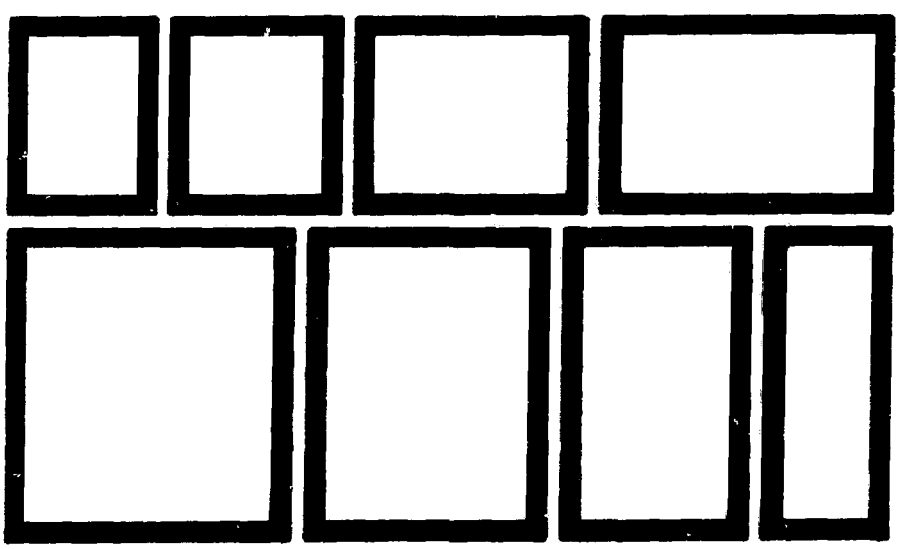

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MALAYSIA

UTILIZATION OF RESEARCH REACTORS IN UNIVERSITIES AND THEIR MEDICAL APPLICATIONS

by

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Utilization of Research Reactors in Universities and Their Medical Applications

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Abstract

In Japan, five research reactors and a critical assembly are operated by the universities, as listed in Table 1. They are opened to all university researchers, the system of which is financially supported by the Ministry of Education, Culture and Science of the Japanese Government.

Here, as an example, the KUR is explained. Usually the KUR is operated eight cycles per year. One cycle consists of the following four week operation.

1. Mainly for researchers from other universities
2. Mainly for researchers in the institute
3. Mainly for beam experiment
4. Sort time (one ~several hours) experiment.

In the weeks of 1~3, the KUR is operated continuously from Tuesday morning to Friday evening. The experiments include studies on physics, chemistry, biology, medicine, engineering etc.

Recently the medical application of research reactors has become popular in Japan. The new technique of the boron neutron capture therapy has been successfully applied to brain tumors and will be to melanoma (skin cancer) in near future.

Table 1. Japanese University Research Reactors and Critical Assembly in Operation

Name of Reactor	Owner Univ.	Reactor type	Max. Power	Start-up	Purpose
UTR-Kinki	Kinki Univ.	UTR	1W	1961. 11	research training
TRIGA Rikkyo	Rikkyo Univ.	TRIGA-II	100kW	1961. 12	research isotope
TRIGA Musashi	Musashi Inst.Tech.	TRIGA-II	100kW	1963. 3	research (medical) isotope
KUR	Kyoto Univ.	Tank type	5000kW	1964. 6	research isotope
YAYOI	Univ.of Tokyo	Fast source	2kW	1971. 4	research training
KUCA	Kyoto Univ.	Multi core	100W	1974. 6	research training

Research Reactors and Critical Assemblies in Japan

Tables 2 and 3 show the lists of Japanese research reactors and critical assemblies in operation.

Utilization of KUR

The Kyoto University Reactor (KUR, 5MW, pool-type) has been widely used by many researchers in various fields. Every year 8,000 man-day researchers come to Kyoto University Research Reactor Institute (KURRI).

Typical studies using the KUR are listed below.

	reference		
Physics	1	Neutron diffraction	Y.Iwata et al.
	2	Standard field	K.Kanda et al.
	3	Ultra cold neutrons	M.Utsuro et al.
	4	Low temperature irradiation	K.Atobe et al.
	5	Small angle neutron scattering	M.Ono et al.
	6	Fission neutron plate	H.Chatani
Chemistry	7	Activation analysis	T.Takeuchi et al.
	8	Boron analysis	T.Kobayashi et al.
	9	Fission products release	T.Tamai et al.
Biology & Medicine	10	Low gamma ray neutron field	K.Kanda et al.
	11	Biological effect of neutrons	M.Akaboshi et al.
Application	12	Neutron radiography	S.Fujine et al.

Among them, the studies associated for neutron capture therapy, boron analysis and neutron radiography are explained by the attached papers, which were recently presented at international meetings held at MIT.

Of course, there are so many publications performed using the KUR, they can not be explained in limited space and time.

Table 2 Japanese Research Reactors in Operation

Name	Owner	Site	Purpose	Type and enrichment		Max. power	Start-up date
JRR-2	JAERI	Tokai	research, radioisotopes	D_2O (CP-5)	U-Al 93 %	10 MW	1960. 10
UTR-10-KINKI	Kinki Univ.	Higashiosaka	research, training	H_2O (UTR)	U-Al 90 %	1W	1961. 11
TRIGA-II -RIKKYO	Rikkyo Univ.	Yokosuka	research, training	H_2O (TRIGA)	U-ZrH 20 %	100 kW	1961. 12
TT -1	Toshiba	Kawasaki	research, training	H_2O (pool)	U-Al 20 %	100 kW	1962. 3
JRR--3	JAERI	Tokai	research, radioisotopes	D_2O (tank)	NU UO_2 1.5 %	10 MW	1962. 9
TRIGA-II -MUSASHI	Musashi Univ.	kawasaki	research, training	H_2O (TRIGA)	U-ZrH 20 %	100 KW	1963. 3
KUR	Kyoto Univ.	Kumatori	research, training, radioisotopes	H_2O (tank)	U-Al 93 %	1 MW (5MW)	1964. 6 (1968. 6)
JRR-4	JAERI	Tokai	shielding, research, radioisotopes	H_2O (pool)	U-Al 93 %	2.5 MW	1965. 1
JMTR	JAERI	Oarai	material test, radioisotopes	H_2O (MTR)	U-Al 93 %	50 MW	1968. 3
YAYOI	Tokyo Univ.	Tokai	research, training	fast (horizontally movable)	U 93 %	2 kW	1971. 4
NSRR	JAERI	Tokai	safety research	H_2O (TRIGA)	U-ZrH 20 %	300kW	1975. 6

Table 3 Japanese Critical Assemblies in Operation

Name	Owner	Site	Type and enrichment		Max. power	Start-up date
SHE	JAERI	Tokai	Graphite (horizontally split)	U 20 %	10 W	1961. 1
TCA	JAERI	Tokai	H_2O (tank)	UO_2 2.6 % UC_2-PuO_2 2.6 %	200 W	1962. 8
OCF	Hitachi	Kawasaki	H_2O (tank)	UO_2 2.5 % UO_2 1.5 %	100 W	1962. 10
NCA	NAIG	Kawasaki	H_2O (tank)	UO_2 3 % UO_2 2 % UO_2 1 %	200 W	1963. 12
JMTRC	JAERI	Oarai	H_2O (pool)	U-Al 90 %	100 W	1965. 10
FCA	JAERI	Tokai	fast (horizontally split)	U 93 % U 20 %	2 kW	1967. 4
MITSUBISHI-CA	MAPI	Omiya	H_2O (tank)	UO_2 13 %	200 W	1969. 7
DCA	NPC	Oarai	D_2O (tank)	UO_2 0.22 % UC_2-PuO_2 1.5 %	1 kW	1969. 12
KUCA	Kyoto Univ.	Kumatori	various (multi-core)	U-Al 93 % U-Al 45 %	100 W 1 kW (short time)	1974. 8

Reactor Physics Education Program for Graduate School Students from Ten Universities

A joint reactor laboratory course of graduate level is offered every summer since 1975 by ten associated Japanese universities with the use of the Kyoto University Critical Assembly, KUCA. It is opened to students for three weeks and a total of 470 students from Hokkaido Univ., Tohoku Univ., Tokyo Institute Technology, Tokai Univ., Musashi Institute of Technology, Nagoya Univ., Kyoto Univ., Osaka Univ., Kobe Univ. of Mercantile Marine and Kyushu Univ. have taken the course in last seven years. The course has been institutionalized with the background that it is extremely difficult for any single university in this country to have her own research or training reactor. By thier effort the united faculty team of the course have succeeded in giving an effective, unique one-week course, taking advantage of their collaboration.

The subjects offered are

(1) critical approach,

(2) control rod callibration,

(3) Feymann α,

(4) flux distribution,

(5) operation training.

Table 4. KUCA Graduate School Student Education Program

1. All leading universities (except U. of Tokyo) are participanting in this program.
2. First authorized system to interchange course credits between Kyoto University and other leading universities.
3. Course credit is 2 units.
4. Travel and living expenses paid by Government of Japan.
5. Lectures given by distinguished professors from participanting U.S.
6. Develops close personal friendships among students that continue in working careers in Government. industries, educational and research institutions.
7. Since 1975, 567 students took this course. (plus 4 U.S. students)

Table 5 Number of Graduate School Students Participated in the MUCA Experiment during 1975-1983

Year	Week	Hokkaido	Tohoku	Tokyo IT.	Tokai	Nagoya	Osaka	Kobe	Kyushu	Musashi IT.	Total	Kyoto Univ.	From USA
1975			4	5	1	5	9				24	19	
1976	1st	5	5		2		6				18		
	2nd			6		6	3		5		20	18	
1977	1st	5	3		1		10				19		
	2nd			5		6	3		7		20	23	
1978	1st	5	3		3		9				20		
	2nd			5		6		4	5		20	26	
1979	1st	5	5		2		10				22		
	2nd			5		7		2	7		21	24	1
1980	1st	6	6		1		8				21		
	2nd			7		7	7				21	21	1
1981	1st	6	4		2		10				22		
	2nd			6		5		3	6	1	21	21	1
1982	1st	6	5			5			7		23		1
	2nd			5	4		9	3		1	22	16	
1983	1st	6				7			7	4	22		
	2nd		6	6	2		9				23	19	
Total		44	40	51	18	53	94	12		9	370	187	4

Total 561

Table 6 Weekly Schedule of KUCA Experiment

	9	12	3	6	9	12
	AM			PM		
MON	REGISTR'N		ORIENT'N		PARTY	
TUE	LEC 1		EXP 1		REPORT	
WED	LEC 2		EXP 2		REP	
THU	LEC 3		EXP 3		REP	
FRI	LEC 4		EXP 4		REP	
SAT	REPORT					

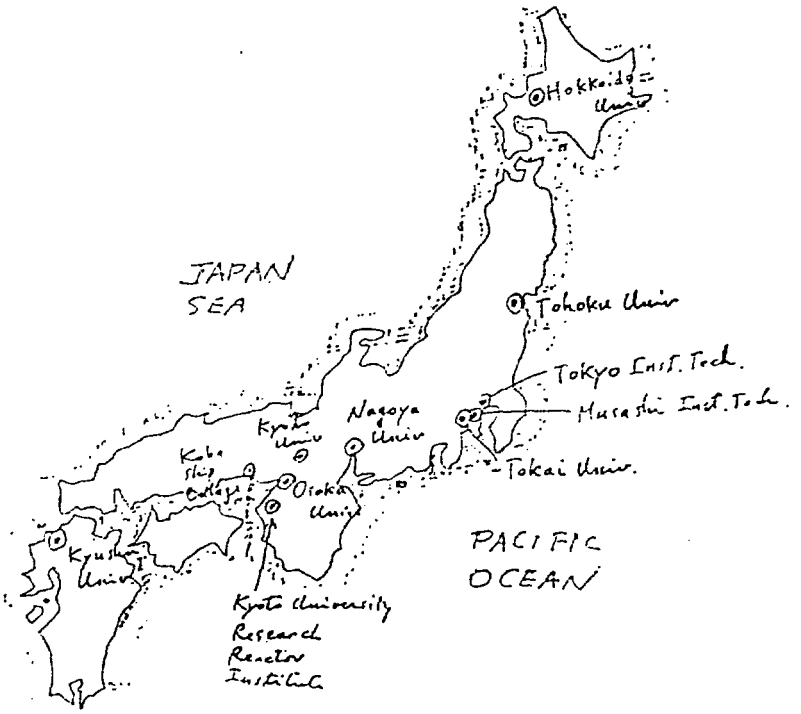

Fig. 1 Locations of Ten Universities and Kyoto University Research Reactor Institute

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