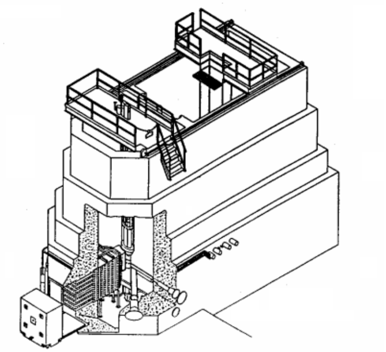
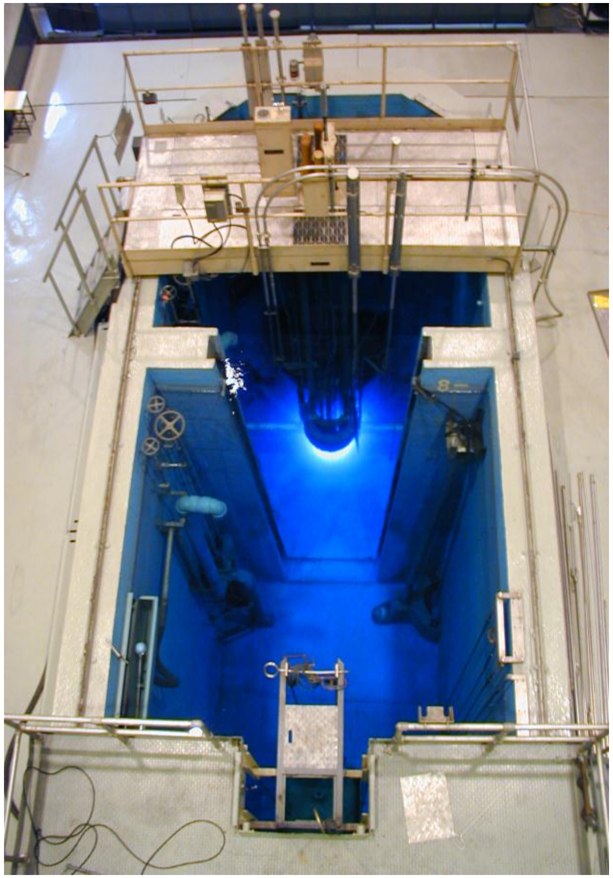
Utilization of Thai Research Reactor (TRR-1/M1)

S. Chue-inta, N. Klaysuban, C. Tippayakul and A. Konduangkaeo

Descriptions of TRR-1/M1



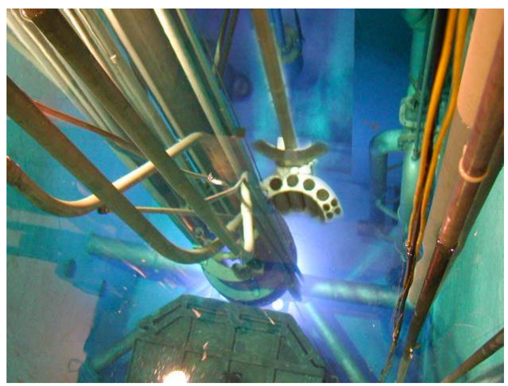


- TRIGA Mark III
- First Critical July 1977
- Max. Power: 2 MW
- Nominal Operation: 1.2 MW
- Flux $3x10^{13}$ $cm^{-2}.sec^{-1}$
- Coolant water

Descriptions of TRR-1/M1

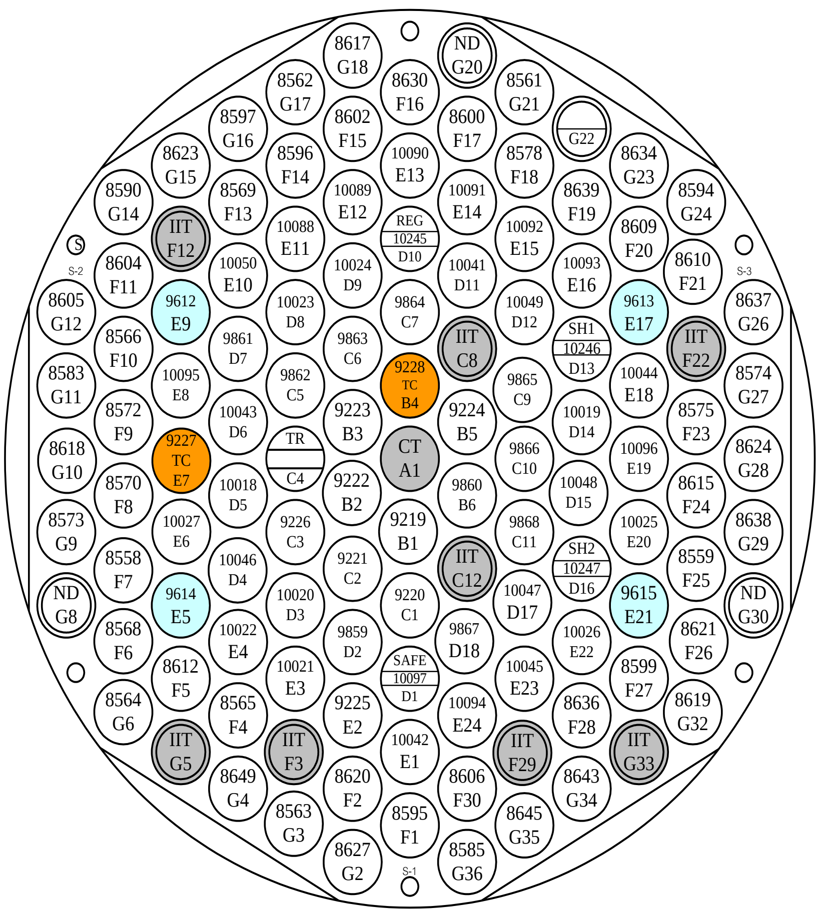
Fuel Elements

- 20% TRIGA rod



- **Control Rods**
- 4 FFCR
- 1 AFCR
- B[4]C

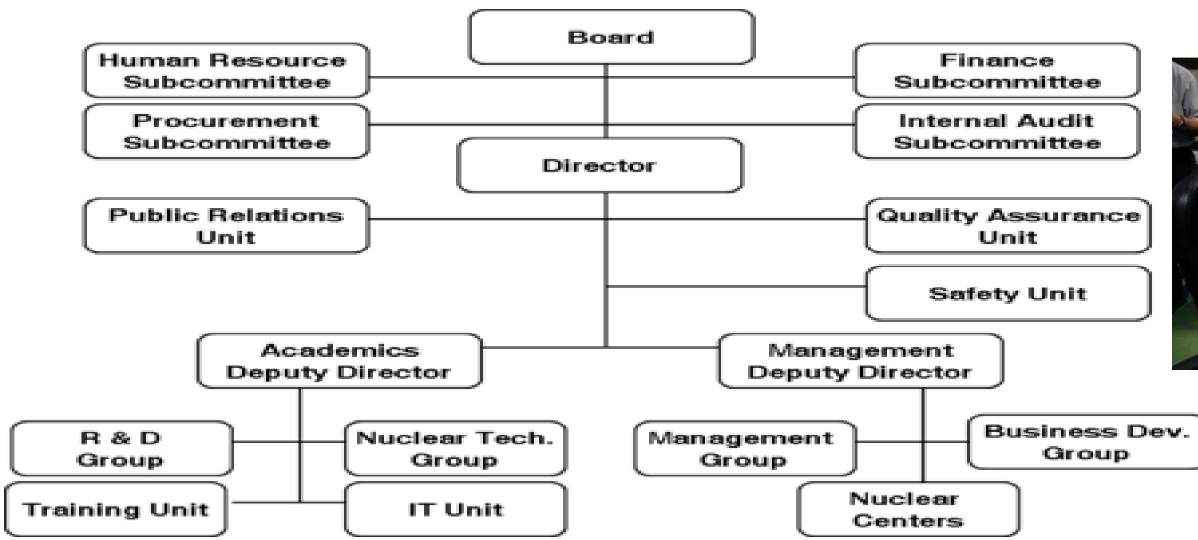
Descriptions of TRR-1/M1



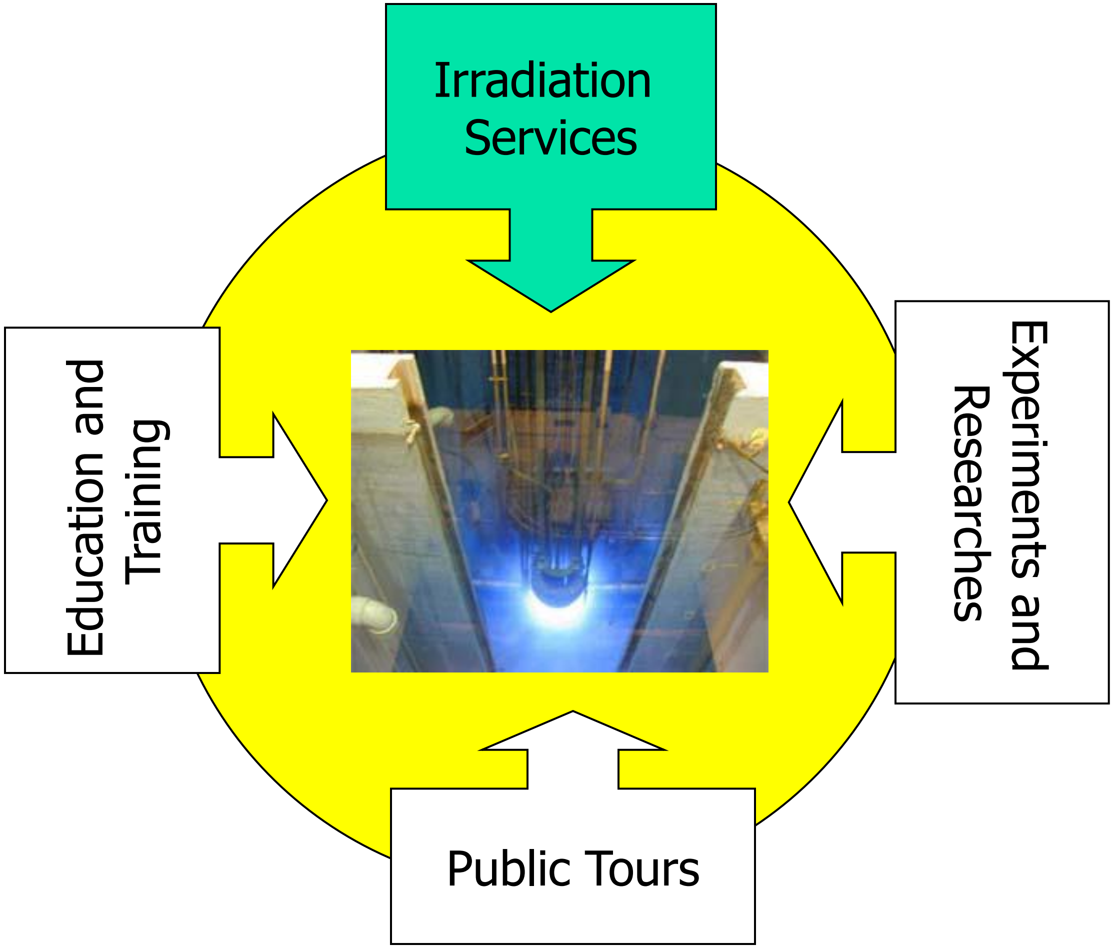
- Current Core Configuration: No. 18
- 107 Fuel elements (4 Fuel Follower Control Rods)
- 9 In-core irradiation positions (CT, C8, C12, F3, F12, F22, F29, G5 and G33)

Operating Organization

- Thailand Institute of Nuclear Technology (TINT)
- Nuclear Technology and Reactor Operation Div.
- Reactor Management Section(11 operators)



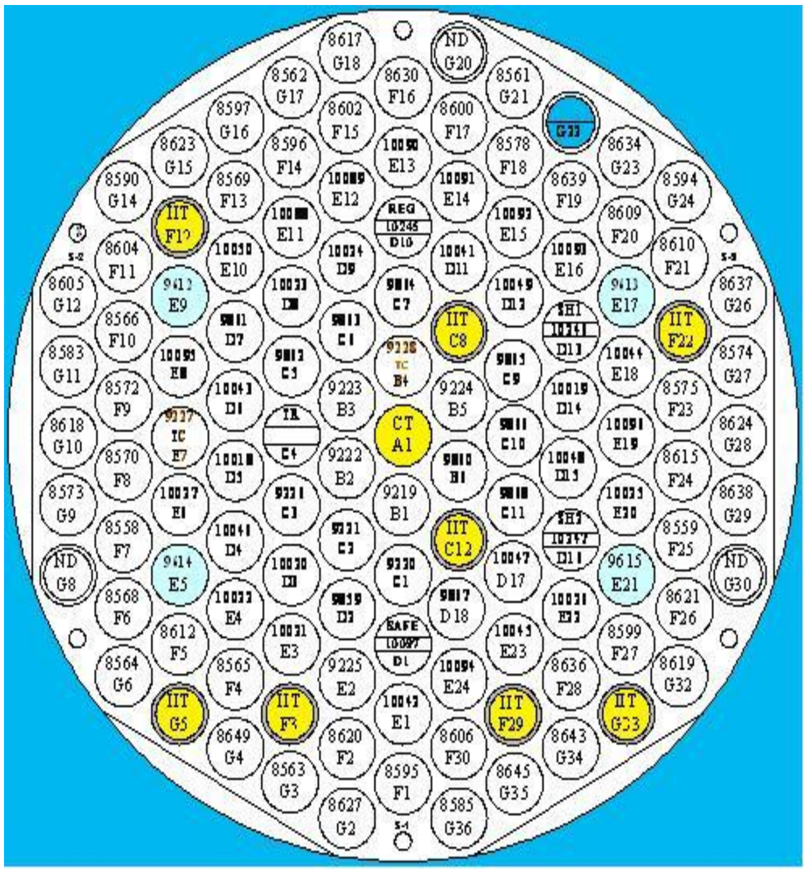
TINT Policy : Equivalent Social and Beneficial Utilization of TRR-1/M1



Operation Schedule

- Operating power: 1200 kW
- Weekly operation schedule: 46 hours / week
  - Monday : Experiments
  - Tuesday-Friday: Operation
- Annual operation schedule: 10.5 months
- Annual maintenance: 1.5 months (Feb-Mar)

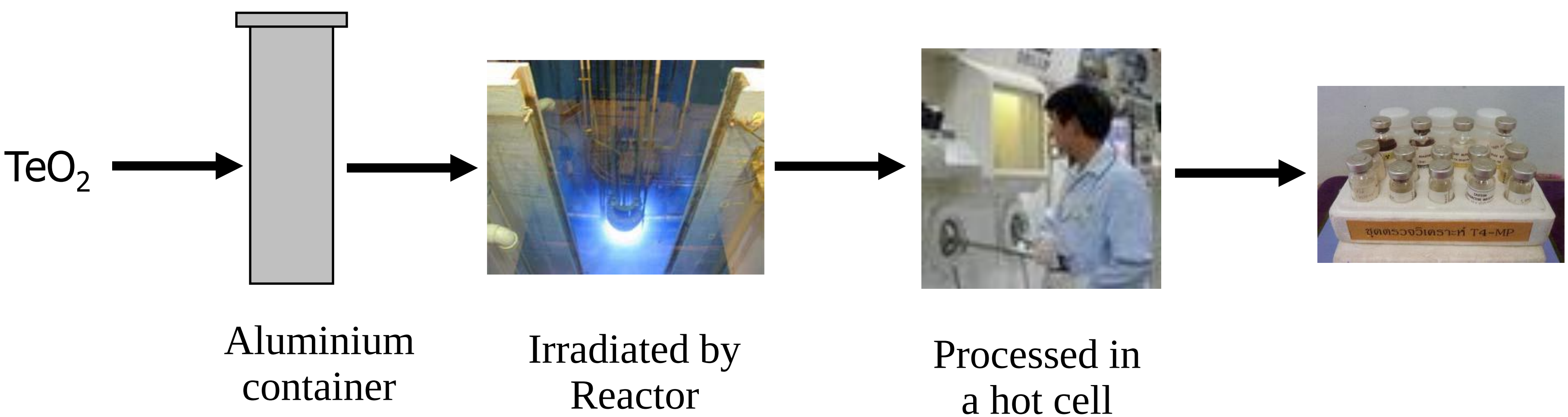
Ten In-core facilities



- CT $3 \times 10^{13} ncm^{-2}sec^{-1}$
- C-ring $2 \times 10^{13} ncm^{-2}sec^{-1}$
- F-ring $1 \times 10^{13} ncm^{-2}sec^{-1}$
- G-ring $9 \times 10^{12} ncm^{-2}sec^{-1}$

Irradiation Service

- Isotope Production
  - Mainly ^{131}I, 5Ci per week ~ half of country's demand
  - ^{153}Sm, ^{32}P and ^{177}Lu on occasional basis



Isotope Production

80gmTeO_2(^{131}I)

CT	**6wks**	**2days, 5mg Sm_2O_3 (^{153}Sm)**
C8	**6wks**	
C12	**7wks**	
F3	**8wks**	**2days, 1mg Lu_2O_3 (^{177}Lu)**
F29	**9wks**	
G5	**7wks**	**1wk, 5gm NH_4HPO_4 (^{32}P)**
G33	**7wks**	

Products and Patients

- ^{131}I Solution 18Ci 1,150 cases
- ^{131}I Diagnostic capsule, 90mCi, 93 cases
- ^{131}I Therapeutic capsule, 126Ci, 3,338 cases
- ^{131}I MIBG diagnostic dose, 133mCi, 138 cases
- ^{131}I MIBG therapeutic dose, 560mCi, 4 cases
- ^{131}I Hippuran, 144mCi, 144 cases
- ^{153}SmEDTMP, 2.2Ci, 34 cases
- ^{32}P 18mCi

Products 147Ci
Values 708,982 $
4,901 patients

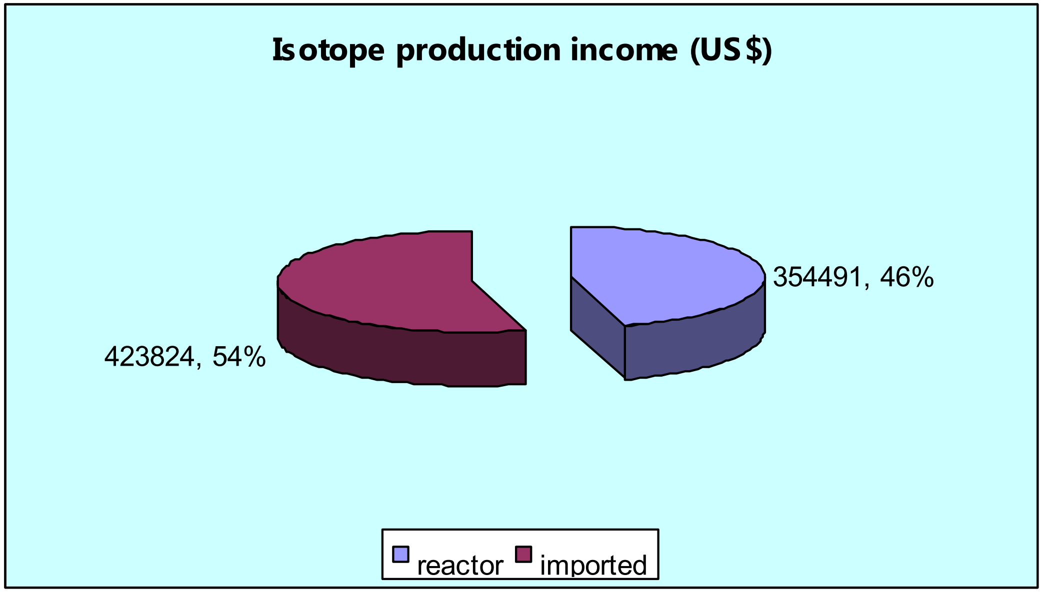
^{99m}Tc Products

- Total import 26Ci (generator 500mCi/week)
- Products from Labs: MAA, MAG3, MDP, DISIDA, DMSA, DTPA, Phytate, Stannous, EC, MIBI, Hynic-TOC

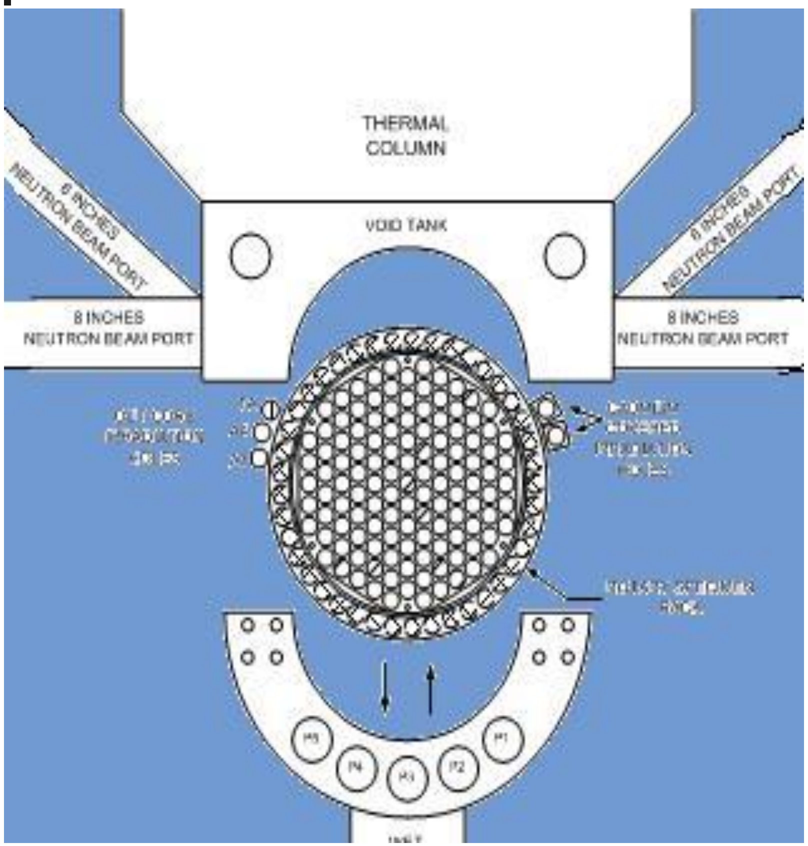
Products 147 units
Values 69,333 $
For 20,252 Patients

Incomes from isotope products

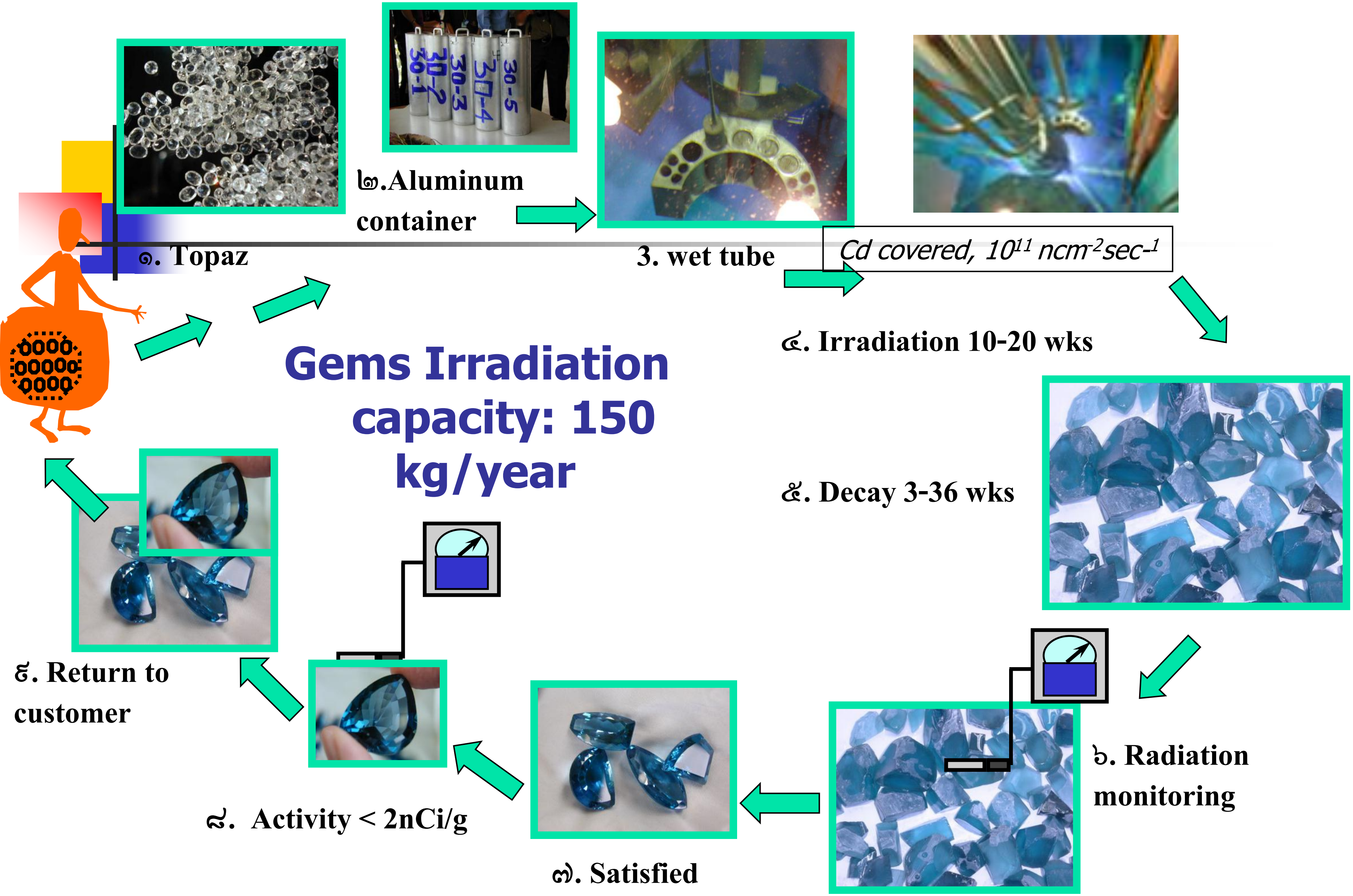
- TRR-1/M1 originated = 354,491 US$
- Generator originated = 423,824 US$



Ten Out-core Irradiation Facilities



- Column $1x10^{9}ncm^{-2}sec^{-1}$
- Beams $1x10^{6}ncm^{-2}sec^{-1}$
- Tubes $1x10^{11}ncm^{-2}sec^{-1}$
- LS $2x10^{11}ncm^{-2}sec^{-1}$
- WT $8x10^{11}ncm^{-2}sec^{-1}$



Gems Irradiation capacity: 150 kg/year
๑. Topaz
๒.Aluminum container
30-1
30-2
30-3
30-4
30-5
3. wet tube
Cd covered, 10^{11} ncm^{-2}sec^{-1}
๔. Irradiation 10-20 wks
๕. Decay 3-36 wks
๖. Radiation monitoring
๗. Satisfied
๘. Activity < 2nCi/g
๙. Return to customer

Beryl
[gamma > 200 Mrad]

Quartz
[gamma]

บุษราคัม
[neutron]

Tourmaline
[gamma]

Diamonds
[neutron & heat]

London Blue
[neutron & heat]

Swiss Blue
[neutron, EB & heat]

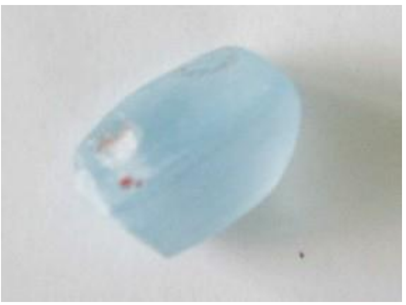
Sky Blue
[EB & heat]

Super Blue
[neutron, EB & heat]

White Topaz Rough

White Topaz Faceted

Topaz
[neutron]



Topaz Performs-Sky Blue
[EB & heat]

Topaz Performs
[EB no heat]

Topaz
[neutron & no heat]

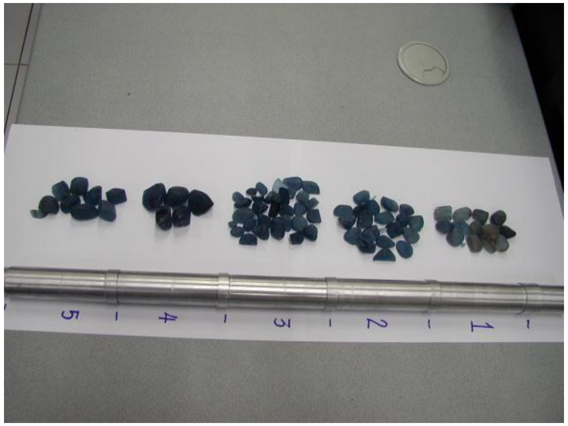
Topaz Faceted
[EB no heat]

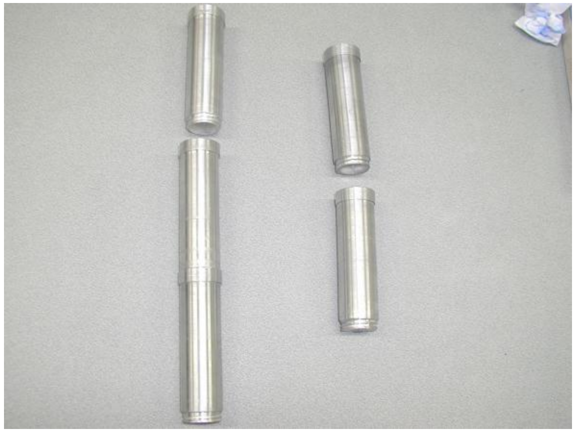
Topaz
[gamma]

Topaz
[neutron & EB]

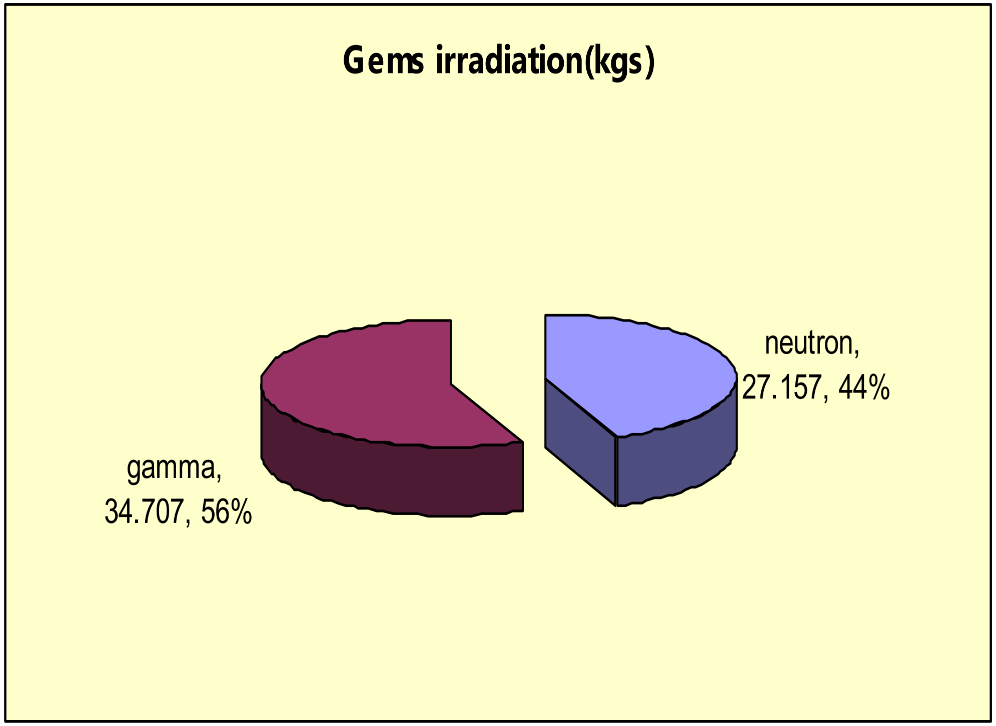
Gems In-core Irradiation

- In-core irradiation facilities (F12, F22, G5 and G33)
- Calculation core reactivity insertion (MVP Code)
- Irradiation tests with 300gm gems for 12-72 hrs





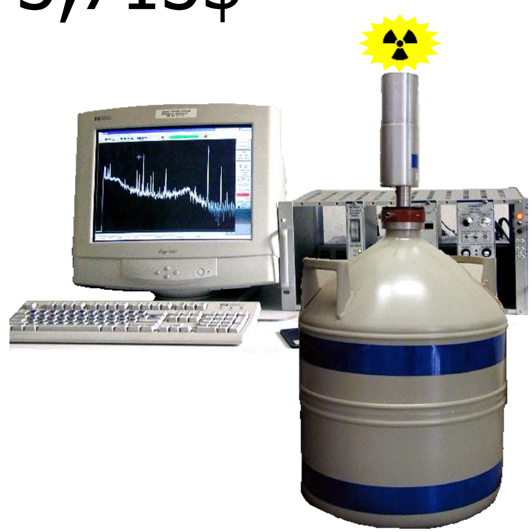
Gems Irradiation Products

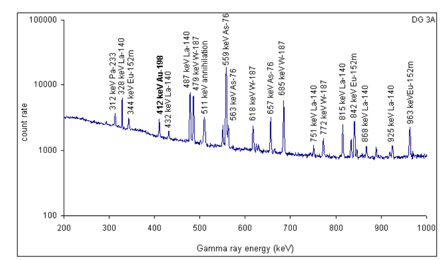


- Reactor 28,826 US$
- Gamma 6,653 US$
- Total 35,479 US$

Irradiation Service

- 3. Neutron Activation Analysis
  - Alloys, minerals, geological, (teeth)
  - Foods, biological, air pollution
  - Incomes 3,713$

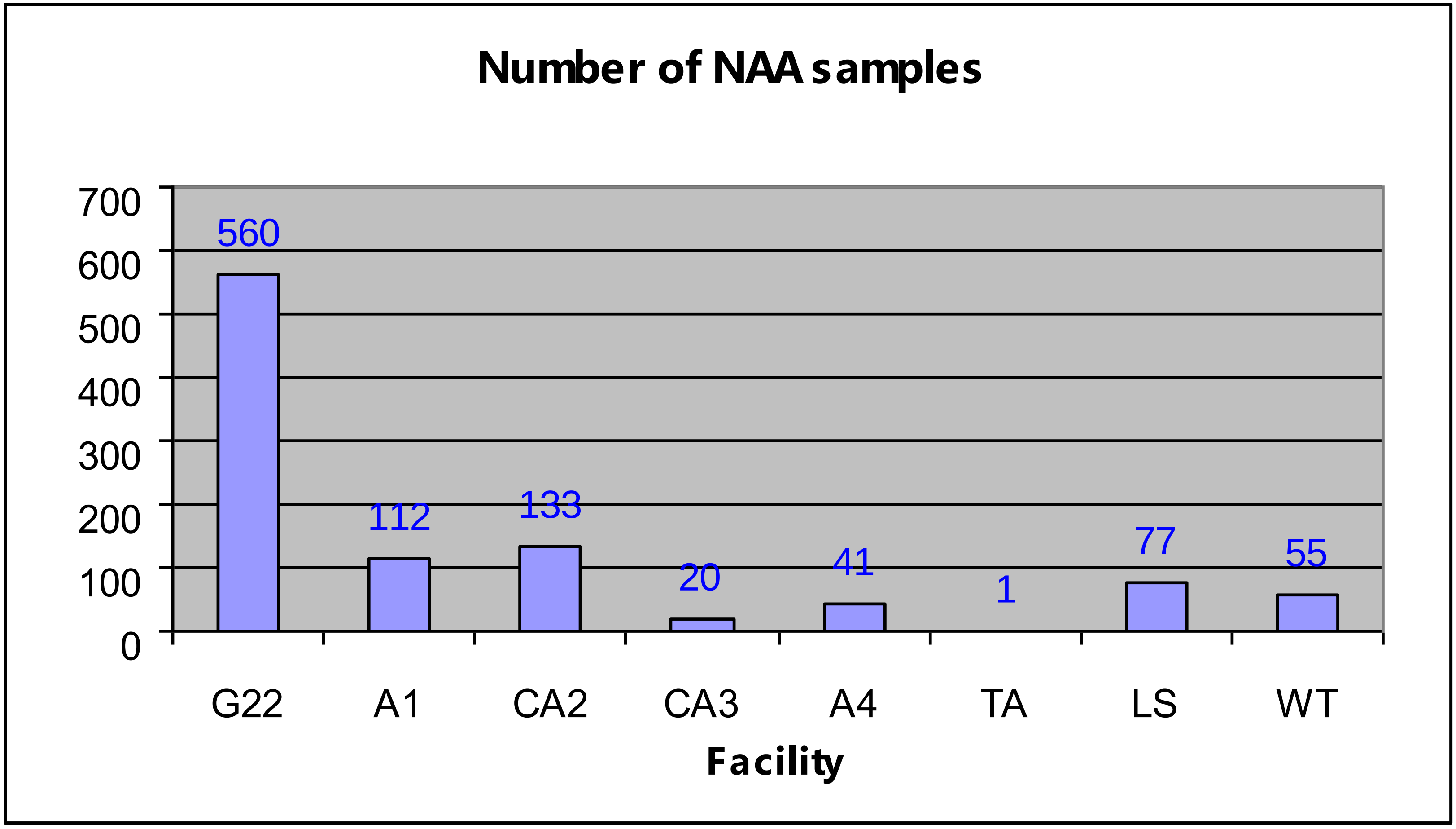




INAA

Type	Elements	irradiation	decay
short	Al, K, Cl, Cu, Mg, Ti, V	Min	5m
short	Mn, Na		3hr
Med	As, Br, K, La, Na, Sb, Sm	Min-day	3days
Long	Ce, Co, Cr, Fe, Sb, Sc, Se, Th, Zn		2wks

INAA income 3,713$

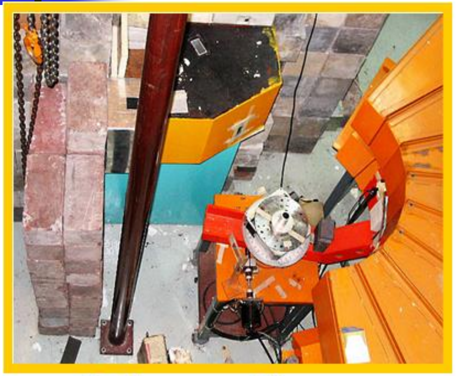


Rough Estimations

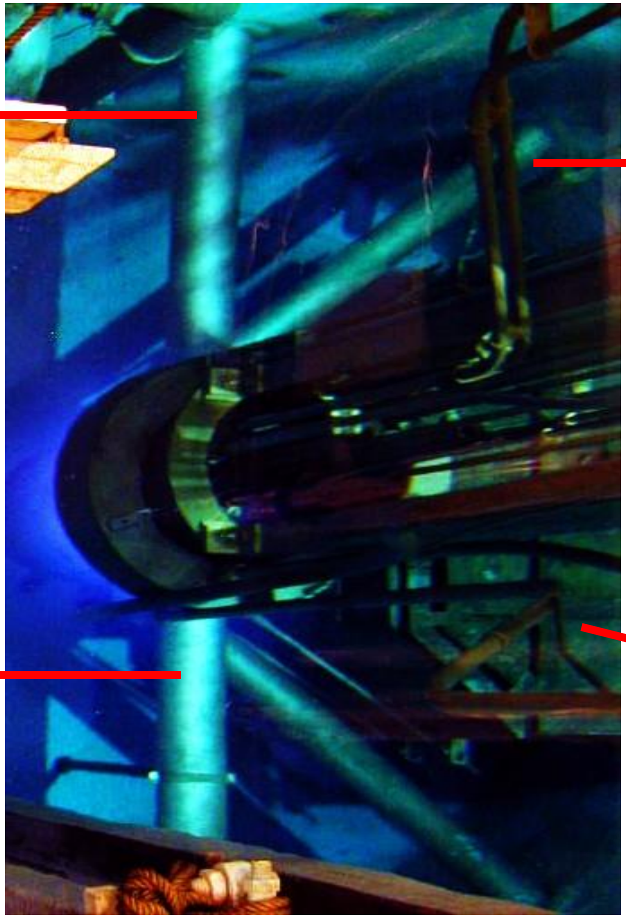
- Incomes (IP+GEMS+NAA)=452,650$
- Operation (Fuel + budget)=2,121,212$
- Incomes/Operation costs = 21.33 %

Research

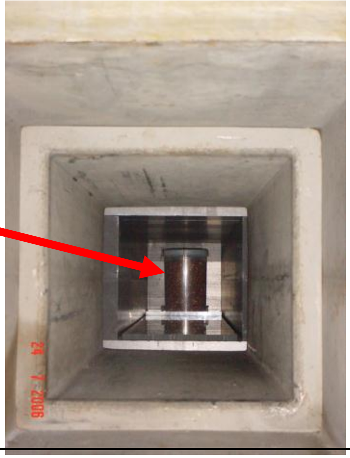
Scattering



Radiography



PGNAA



Large sample INAA

DEVELOPMENT OF A PROFILE DATA ACQUISITION SYSTEM FOR NEUTRON COMPUTED TOMOGRAPHY FOR THE THAI RESEARCH REACTOR TRR-1/M1

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ABSTRACT

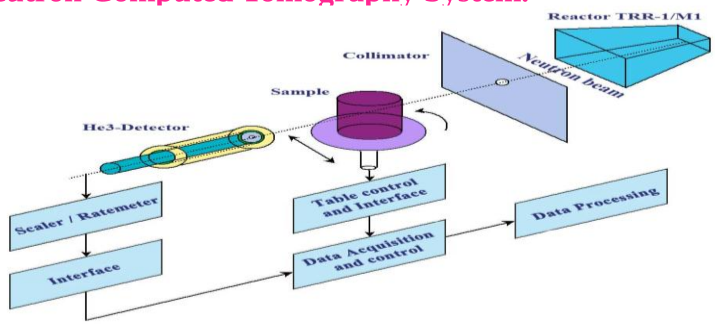
The neutron computed tomography using Thai research reactor TRR-1/M1 was developed in this research. The system was divided into two parts. The first one is the rotate-translate system and the second is the data acquisition program. The collected profiles data was 1 mm/step of translation and 7.2 degree/step angle of rotation .The neutron beam from Thai research reactor TRR-1/M1 which is operated at 1200 kilowatts. The neutron CT images were found to be satisfactory.

INTRODUCTION

The objective of this research is to develop the neutron computed tomography system for TRR-1/M1. The neutron computed tomography is one of the widely used Non-Destructive Testing (NDT) methods. The principle of this technique is to measure the intensity of neutrons attenuated by different materials in the object. Two dimensional images of the object are derived from the measurement. By rotating the object in small increment, several 2D images of the object are taken at different angles and they are finally combined to construct a cross sectional view by computed tomography methodology.

EXPERIMENTAL & RESULTS

Neutron Computed Tomography System.

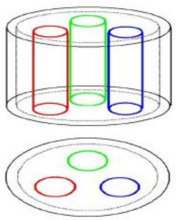


Equipment installation

Data Acquisition and Data Processing

Table control

Neutron image processing

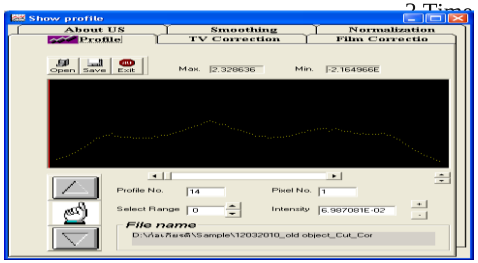


Detail of objects

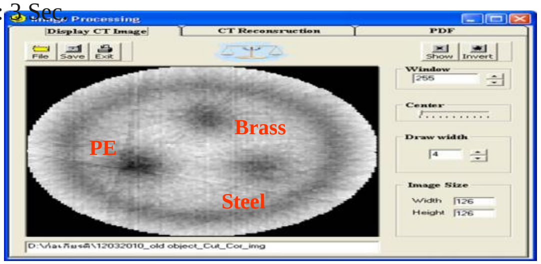
1.PVC cover diameter 12 cm.
thickness 0.8 cm
2.Steel diameter 2 cm
3.PE diameter 2 cm
4.Brass diameter 2 cm

Detail of scan

1.Profiles : 26
2.Ray sums : 140
3.Time : 3 Sec.



Projection Data



CT Image

CONCLUSIONS

Through this study of neutron computed tomography using thermal neutron beam from TRR-1/1M, the obtained image could be identified the difference kind of materials such as PE, Steel and Brass by the CT-number.

CT image was reconstructed from the projection data, because of the neutron scattering reduces the contrast of CT image. So, the scattering neutron correction should be considered.

SENSITIVITY OF NEUTRON IMAGING PLATE TO NEUTRONS AND GAMMA-RAYS

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ABSTRACT

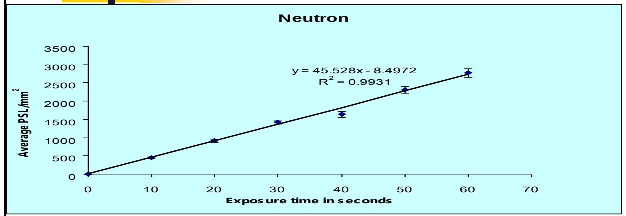
The objective of this research is to investigate the sensitivity of a Fuji BAS-ND 2040 neutron imaging plate to neutrons and gamma-rays for non-destructive testing of some ancient specimens. For sensitivity to neutrons, the imaging plate was exposed to neutrons from a neutron beam of the Thai Research Reactor TRR1/M1 operating at 1.2 MW having a neutron flux of 1.26×10^6 n/cm^2-s and a cadmium ratio of approximately 250. It was found that the photostimulated luminescence (PSL) output increased linearly with increasing of the exposure time and the sensitivity to neutrons was approximately 1 PSL per 280 neutrons. For sensitivity to gamma-rays, it was exposed to 661.6 keV gamma-rays from 10 μCi Cs-137 source. The sensitivity was found to be approximately 1 PSL per 4.8×10^3 gamma-ray photons. The sensitivity of the imaging plate to neutrons was, therefore, about 17 times faster than to the gamma-rays which was very high comparing to the conventional film technique. Finally, the imaging plate was employed to record neutron and x-ray radiographic images of some ancient specimens. The image quality was comparable to those obtained from the conventional film technique with significantly reduction of the exposure time.

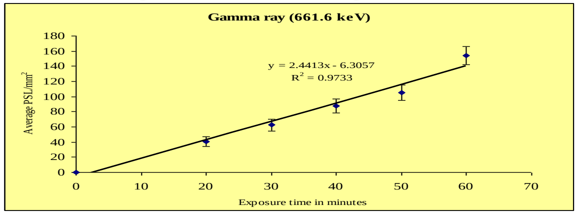
INTRODUCTION

Neutron Radiography is one of non-destructive testing (NDT) methods. Currently imaging plates have been used in place of or along with traditional X-ray or photographic films. X-ray film imaging usually takes a long time to process before the image is obtained. The imaging plates, on the other hand, are more sensitive to radiation and therefore will take much shorter time to process. In this study we used an imaging plate reader which uses laser beams to interact with imaging plates. The output came out as computer-readable data, which is convenient to be analyzed. In this study we investigated the sensitivity of the imaging plates to neutron and gamma radiation in order to use the plates in studying some ancient specimens in the future.

EXPERIMENTAL & RESULTS

1. Linearity and Sensitivity test





For slow neutrons with Cd ratio of ~ 250 :

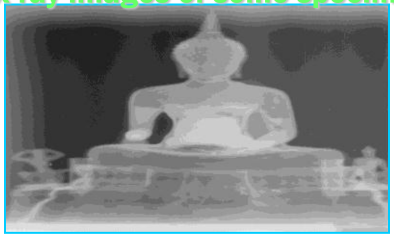
NIP requires ~ 280 n/cm^2 to obtain 1 PSL/mm^2 read out i.e. having a sensitivity of ~ 3.6×10^{-3} PSL/mm^2 per neutron

For gamma-rays from Cs-137 (661.6 keV) :

NIP requires ~4.8×10^3 γ/cm^2 to obtain 1 PSL/mm^2 read out i.e. having a sensitivity of ~ 2.08×10^{-4} PSL/mm^2 per gamma-ray photon

Average PSL readout from NIP VS exposure time

2. Neutron and x-ray images of some specimens



(left : Ancient specimen; middle : NR using NIP; right : x-ray radiography using x-ray IP)

CONCLUSIONS

❶ Neutron Imaging Plate is more sensitive to neutron radiation than to gamma rays or x-rays.

❷ Neutron Imaging Plate 's speed is about 40 times faster than the conventional film technique.

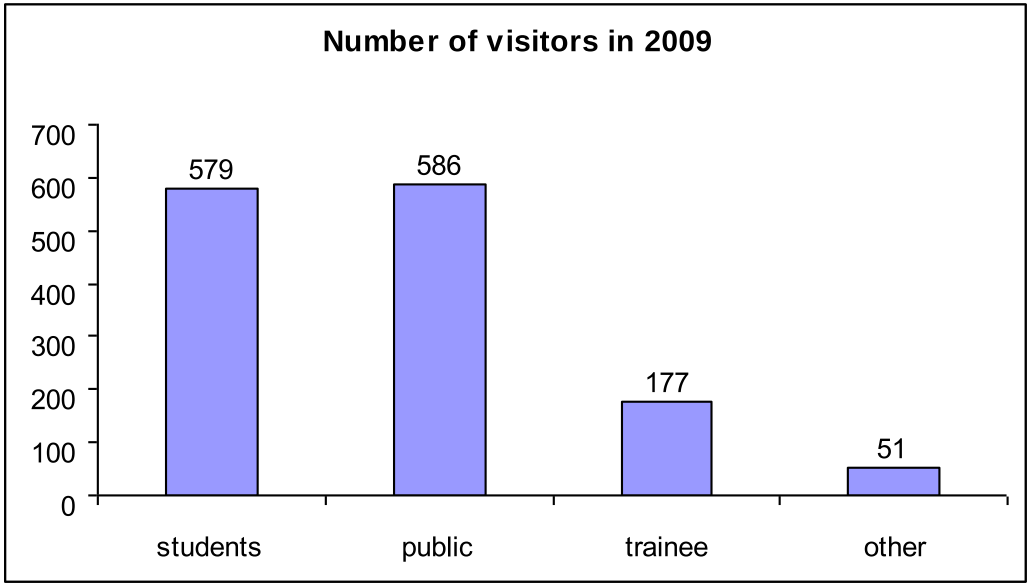
❸ This can be applied to neutron radiography using Neutron Imaging Plate for inspection ancient objects.

Education and Training

- Cooperation
  - Criticality
  - Thermal Hydraulic
  - Neutronics
  - Operation

- Maintenance
- Safety culture
- Radiation protection
- Inspection
- Quality Assurant
- Utilization

Public Tours



Conclusions

- TINT has equivalent policy towards social and beneficial utilization of TRR-1/M1
- Estimated incomes/operation cost 21.33%
- Will try to improve….KM, training, Cooperation, etc.

Thank you for kind attention