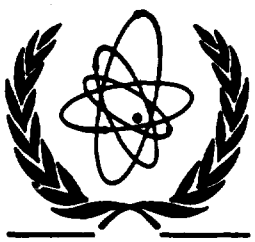

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STATUS REPORT OF THE PROGRAM ON
NEUTRON BEAM UTILIZATION
AT THE DALAT NUCLEAR RESEARCH REACTOR

Vuong Huu Tan
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Dalat, Vietnam

August 1996

IAEA NUCLEAR DATA SECTION, WAGRAMERSTRASSE 5, A-1400 VIENNA

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ABSTRACT

The thermal reactor is an intense source not only of thermal neutrons, but also intermediate as well as fast neutrons. Using the filtered neutron beam technique at steady state atomic reactor allows receiving the neutrons in the intermediate energy region with the most available intense flux at present. In the near time at the Dalat reactor the filtered neutron beam technique has been applied. Utilization of the filtered neutron beams in basic and applied researches has been an important activity of the Dalat Nuclear Research Institute (DNRI). This report presents some relevant characteristics of the filtered neutron beams and their utilization in nuclear data measurements, neutron capture gamma ray spectroscopy, neutron radiography, neutron dose calibration and other applications.

I. INTRODUCTION

The research reactor IVV-9 of the Dalat Nuclear Research Institute (DNRI) after the completion of its renovation and upgrading from the previous TRIGA reactor has been operating at its power level of 500 kW since 1984 [1]. From that time the research program on effective utilization of horizontal experimental channels of the reactor was conducted. For this purpose investigations on physical characteristics of the reactor; neutron spectra and fluxes at these channels; safety conditions in their exploitation have been carried out. However, before 1988 the reactor was mainly used for isotope production and neutron activation analysis

and no beam channels were utilized. From 1988 the filtered thermal neutron beam at the tangential channel No.3 was extracted using a single crystal silicon filter and used for prompt gamma neutron activation analysis (PGNAA), neutron radiography (NR) and transmission experiments (TE), In 1990 we began the program for extracting filtered quasi-monoenergetic keV neutron beams at the piercing horizontal channel No.4 using the neutron filter technique. Utilization of these filtered neutron beams in nuclear data measurements and applied researches has been carried out.

Table 1

Main characteristics of the filtered thermal neutron beam

Composition of the filter assemblies	ϕ(th) $n.cm^2.s^{-1}$	ϕ(E > 1MeV) $n.cm^{-2}.s^{-1}$	R(Cd/Au)	I(gamma) (R/h)
No filter	$5.8x10^7$	$4.5x10^5$	5	4
80 mm C + 50mm Pb	$1.2x10^7$	$3.5x10^4$	12	1.8
80 mm C + 100 mm Pb	$5.5x10^6$	$1.2x\ 10^4$	19.5	0.8
Comp. No 2 +366 mm Si	$3.5x10^6$	$n\ x10^1$	77.5	0.22

II. THE FILTERED NEUTRON BEAMS AT THE DALAT REACTOR

Up to now at the Dalat reactor two horizontal experimental channels were utilized. On the tangential channel the filtered thermal neutron beam was extracted, its characteristics with some filter assemblies are shown in Table 1 [2].

In the piercing channel No.4 some kinds of neutron filters such as Si, Al, Fe, S, Ti, B have been installed to produce quasi-monoenergetic neutrons of 24 keV, 25 keV, 55 keV, 75 keV, 144 keV as well as thermal neutrons. The fluxes and other characteristics of these filtered neutron beams are given in Table 2 [3].

III. UTILIZATION OF THE FILTERED NEUTRON BEAMS

3.1. Neutron Physics and Nuclear Data [3]

In the keV energy region filtered beams are the most intense neutron sources which can be used to obtain neutron data for reactors and other applications. The following experiments have been carried out at the Dalat reactor:

- Total neutron cross section measurements for ^{238}U, Fe, Al, Pb on filtered neutron beams of 144 keV, 55 keV, 25 keV and evaluation of average neutron resonance parameters from experimental data.
- Gamma ray spectra from neutron capture reaction of some reactor materials on filtered neutron beams of 55 keV and 144 keV.
- Average neutron radiative capture cross sections of ^{238}U for 55 keV and 144 keV neutrons.
- Isomeric ratio of $^{82m,g}Br$ created in the reaction $^{81}Br(n,\gamma)^{82}Br$ for 55 keV and 144 keV neutrons.
- Other investigations such as average resonance capture measurements, $(n,2\gamma)$ reaction, etc.

Table 2

The characteristics of filtered neutron beams at the channel No.4

Neutron	Filter combination	$\Phi(n/cm^2.s)$	R_{cd} or FWHM
Thermal	98cm Si + 10cm Ti + $35g/cm^2$ S	$1.8x10^7$	143
144 keV	98cm Si + 10cm Ti + $0.2g/cm^2$ B^{10}	$1.2x10^7$	22 KeV
55 KeV	98cm Si + 35g/cm2 S + $0.2g/cm^2$ B^{10}	$4.0x10^6$	8 KeV
25 KeV	102.3cm Al + $0.2g/cm^2$ B^{10}	$1.2x10^6$	
24 KeV	20cm Fe +20cm Al +$25g/cm^2$ S +$0.2g/cm^2$ B^{10}	$1.0x10^6$	
75 KeV	$45g/cm^2$ S + $0.2g/cm^2$ B^{10}	$1.1x10^6$	

3.2. Applied Neutron Capture Gamma Ray Spectroscopy [2,3]

- Design and arrangement of the Compton-suppressed and pair spectrometer for neutron in-beam researches.
- Development of prompt gamma neutron activation analysis (PGNAA) technique using the filtered thermal neutron beam in combination with the Compton-suppressed spectrometer for analyzing Fe, Co, Ni, C in steel samples; Si, Ca, Fe, Al in cement samples; Gd, Sm, Nd in uranium ores; Sm, Gd in rare earth ores; etc.
- Utilization of the PGNAA method for investigating the correlation between boron and tin concentrations in geological samples as a geochemical indication in exploration and assessment of natural mineral resources; analyzing boron in sediment and sand samples to complement reference data for river samples.
- Utilization of the PGNAA method for comparing boron concentrations in natural ginsengs and in callus ginsengs obtained by the plant tissue culture technique to choose the suitable culture medium, the quantity of trace elements needed to add as well as to apply some relevant procedure of tissue culture process; for determining the nitrogen concentration in various categories of animal food.
- Development of the PGNAA method for in-vivo activation analysis of essential elements Ca, Cl, N and P in the whole body and of the toxic elements Cd, Hg in a body organ for medical diagnosis of various diseases.
- Development of the spectrometer of summation of aplitudes of coinciding pulses for (n,2γ) reaction research and for measuring activity of activated elements with high possibility of cascade transitions.

3.3. Other Applications [2,3]

- Development of neutron radiography method as a NDT technique for various kinds of objects such as electrical and electronic products, mechanical devices, etc.
- Utilization of the filtered neutron beams for research on estimation of the radiobiological effectiveness (RBE) of different energy neutrons and on calibration of neutron dosimeters.
- Utilization of transmission measurements on the thermal neutron beam for determining thermal neutron absorption cross section of samples from drillholes in oil and gas exploitation and for determining boron content distribution along glass tubes used in the electric fluorescent lamp industry.
- In the world neutron scattering techniques have been used very effectively for the structure analysis of superconductors, magnetic materials, actinides, monolayer molecules, martensite alloys, ceramics,...; and for studying various excitations in the condensed matter such as spin-wave of heavy fermion system,

magnetic scattering and phonton of the pseudo two-dimentional materials, lattice dynamics of supper ionic conductors and martensite alloys, ... In the framework of the program on neutron beam utilization of the Dalat Nuclear Research Reactor we have proposed an IAEA Project on the Small Angular Neutron Scattering (SANS) Facility for the period 1996-2000. The SANS facility will be effectively used in research of molecular biology; for a structural analysis of homopolyner in block copolymer microdomains which is very interesting problem in morphology of the polymer mixtures and for studying microstructure of Co-Cr thin films which is a promising material for magnetic recording with higher recording density, etc.

IV CONCLUSION AND DISCUSSION

The neutron filter technique has been used at the Dalat reactor and produced quasi-monoenergetic neutron beams which have a relatively high neutron flux density despite the low reactor power and a low photon contribution. These beams and other scientific equipment have been used for research on neutron physics and nuclear data, and for applications in sciences and life. Many new investigations can be conducted on the filtered neutron beams such as nuclear structure research, boron neutron capture therapy, etc. In order to improve the quality of our results and to open new research the facility and spectrometers have to be upgraded and equipped. In conclusion we can say that beside research and applications our filtered neutron beams, research equipment and methods are basic for training scientific and engineering personnel at the service of the future National Atomic Power Program.

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REFERENCES

1. Tran Ha Anh, " Nuclear Research Institute: Ten years of edification and maturation", Proceeding of the Conference Arranged for 10th Anniversary of DNRI, Nov. 24-25, 1994, p.1, Nuclear research Institute, Dalat (1994).
2. Pham Duy Hien et al., " Exploitation of the Dalat Nuclear Research Reactor", Report of the National Research Contract 50A-01-03 for the period 1985-1990s., Nuclear research Institute, Dalat (1990).
3. Vuong Huu Tan et al., "Utilization of Horizontal Experimental Channels of the Dalat Nuclear Research Reactor", Report of the National Research Contract KC-09-08 for the period 1991-1995s. Nuclear Research Institute, Dalat (1995).

APPENDIX 1
RESEARCH CONTRACTS OF THE PROGRAM ON NEUTRON BEAM UTILIZATION AT DNRI

1. Exploitation of the Dalat Nuclear Research Reactor for the period 1984-1985
   Chief Scientific Investigator: Prof. Pham Duy Hien
2. Exploitation of the Dalat Nuclear Research Reactor for the period 1986-1990
   Chief Scientific Investigator: Prof. Pham Duy Hien
3. Utilization of Horizontal Experimental Channels of the Dalat Nuclear Research Reactor for the period 1991-1995
   Chief Scientific Investigator: Dr. Vuong Huu Tan
4. Exploitation of Neutron Beams at the Dalat Nuclear Research Reactor for the period 1996-2000
   Chief Scientific Investigator: Dr. Vuong Huu Tan

APPENDIX 2
SCIENTIFIC REPORTS AND PUBLICATIONS
(1990-1996)

1. Pham Duy Hien et al. Utilization of the filtered neutron beams at the Dalat Nuclear Research Reactor // Proc. of 2nd Asian Symposium on Research Reactors, ASRR-III, Tokyo, November 1991.
2. Vo Dac Bang et al. Measurement of thermal neutron absorption cross sections of small samples by the poisoning method // The International Workshop

RCM on Nuclear Techniques in Exploitation of Natural Resources, Debrecen, Hugary, 15-19 April 1991.

3. Luong Ngoc Chau et al. Neutron radiography at the Dalat Nuclear Research Reactor // Communications in Physics, Vol.1, No.3, 1991.
4. Luong Ngoc Chau et al. The Prompt gamma neutron activation analysis at the Dalat Reactor // J. Radioanal. Nucl. Chem., Letters, 165 (6) 351-362 (1992).
5. Pham Duy Hien et al. Total neutron cross section of U-238 as measured with filtered neutrons of 55 keV and 144 keV // IAEA report , INDC(NDS)-265, Vienna, October 1992.
6. Vuong Huu Tan et al. The Wall effect correction of the recoil proton counter SNM-38 // Proc. of 1st Conference on Physics in Hochiminh City, 6-7 August 1993.
7. Pham Duy Hien et al. On the contribution of prompt gamma neutron activation analysis to the element characterization of environmental objects // Proc. of 2nd International Workshop on Neutron Activation Analysis in Environment, Dubna, September 1992
8. Pham Duy Hien et al. The Quasi-monoenergy filtered neutron beams at the Dalat Nuclear Research Reactor // Proc. of 4th Vietnam Conference on Physics, Hanoi, 5-8 October 1993.
9. Pham Duy Hien et al. The Compton-suppressed and pair spectrometer for studying neutron capture gamma rays on the filtered neutron beams at the Dalat Nuclear Research Reactor // Proc. of 4th Vietnam Conference on Physics, Hanoi, 5-8 October 1993.
10. Pham Duy Hien et al. Gamma rays from average resonance capture of the filtered neutron beams for some structural and shielding materials // Proc. of 4th Vietnam Conference on Physics, Hanoi, 5-8 October 1993.
11. Pham Duy Hien et al. Analysis of everage neutron radiative capture cross sections // Proc. of 4th Vietnam Conference on Physics, Hanoi, 5-8 October 1993.
12. Vuong Huu Tan et al. The Method of total neutron cross section measurements on the filtered neutron beams at the Dalat Nuclear Research Reactor // Proc. of 4th Vietnam Conference on Physics, Hanoi, 5-8 October 1993.
13. Vuong Huu Tan. Utilization of the filtered neutron beams at the Dalat Nuclear Research Reactor: Staus and Prospects // Proc. of the Hanoi International on Nuclear Physics "Prospects of Nuclear Physics in the Late Nineties", Hanoi, 14-18 March, 1994.
14. Pham Duy Hien et al. Neutron transmission data analysis of U-238 on the filtered neutron beams of 55 keV and 144 keV // Proc. of the IAEA Workshop

on Research Reactor Utilization, Lucas Heights, Sydney, Australia, 26 April to 13 May 1994.

15. Pham Duy Hien et al. Total and radiative capture cross sections of U-238 on the filtered neutron beams of 55 keV and 144 keV // Proc. of the IAEA Workshop on Research Reactor Utilization, Lucas Heights, Sydney, Australia, 26 April to 13 May 1994.
16. Vuong Huu Tan. Nuclear physics researches on the horizontal channels of the Dalat Nuclear Research Reactor // Proc. of the Conference arranged for the tenth Anniversary of the Dalat Nuclear Research Reactor, Dalat, 24-25 November 1994.
17. Vuong Huu Tan et al. Investigation of neutron and gamma dose rate at the sample irradiation position in the thermal column of the Dalat reactor // The report of the Dalat Nuclear Research Institute, Dalat, 1995.
18. Vuong Huu Tan. Nuclear data activity at the Dalat Nuclear Research Institute // Japan Nuclear Data Newsletter, No.52, October 1995, ISSN 0385-4876, p.32
19. Vuong Huu Tan. Nuclear data activities in Vietnam // Proc. of the 1995 Symposium on Nuclear Data, November 16-17, 1995, JAERI, Tokai, Japan, p.77
20. Vuong Huu Tan. Study of nuclear data and applied nuclear physics at the Dalat Institute for Nuclear Research // The IAEA Report, INDC(VN)-007, Vienna, October 1995.
21. Vuong Huu Tan and Tokio Fukahori. Calculation of neutron cross sections for ^{56}Fe from 1 MeV to 50 MeV // Proc. of 1st Conference on Nuclear Physics and Techniques, Hanoi, 14-15 May, 1996.
22. Nguyen Canh Hai et al. Thermal neutron macroscopic absorption cross section measurement at the Dalat Reactor // Proc. of 5th Asian Symposium On Research Reactors, May 29-31, 1996, Taejon, Korea
23. Vuong Huu Tan et al. Measurement of capture cross sections for ^{238}U on the filtered keV-neutron beams // The IAEA Report, Vienna, 1996.
24. Vuong Huu Tan et al. In-beam neutron capture gamma ray spectrometer for basic and applied researches // The IAEA Report, Vienna, 1996.
25. Vuong Huu Tan et al. Fast cyclic activation facility for short hafe-life isotopes measurements // The IAEA Report, Vienna, 1996.
26. Nguyen Trong Hiep et al. Prompt gamma-ray neutron activation analysis facility using HPGe-detector in Compton-suppression technique // Proc. of 5th Asian Symposium On Research Reactors, May 29-31, 1996, Taejon, Korea.
27. Vuong Huu Tan. Status report of the program on neutron beam utilization at the Dalat Nuclear Research Reactor // The IAEA Report, Vienna, 1996.

28. Vuong Huu Tan. Status report on neutron radiography in Vietnam // Proc. of IAEA Expert Meeting for Evaluation of Country Programmes on Neutron Radiography, Serpong, Jakarta, Indonesia, 13-17 May, 1996.
29. Vuong Huu Tan. Utilization of horizontal experimental channels of the Dalat Reactor for researches and applications // Proc. of 10th Pacific Basin Nuclear Conference 10-PBNC, Kobe, Japan 20-25 October, 1996.
30. Nguyen Trong Hiep et al. Thermal neutron capture prompt gamma analysis for the element determination in environmental objects // Proc. of 10th Pacific Basin Nuclear Conference 10-PBNC, Kobe, Japan 20-25 October, 1996.

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