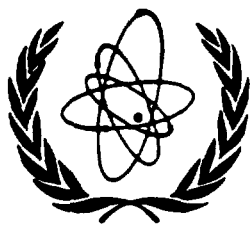International Atomic Energy Agency

INDC

INTERNATIONAL NUCLEAR DATA COMMITTEE

PROGRESS REPORT

ON RESEARCH OF NUCLEAR DATA AND APPLIED NUCLEAR PHYSICS

AT NUCLEAR RESEARCH INSTITUTE (VIETNAM)

for the Period January 1st - December 31st 1996

Edited by

Vuong Huu Tan

Nuclear Physics Department
Nuclear Research Institute
. 1 Nguyen Tu Luc, Dalat
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PREFACE

To promote exchange of information on nuclear data and applied nuclear physics among nuclear physicists in Vietnam and between Vietnam and other member states of IAEA, the Nuclear Physics Department (Nuclear Research Institute, Dalat, Vietnam) will prepare annual Progress Report on activities of nuclear data and applied nuclear physics at the Nuclear Research Institute for every year from January 1st to December 31th. The report will contain information on activities of nuclear data and applied nuclear physics that were carried out at the Nuclear Physics Department for that period. It provides a review of status of experimental and theoretical researches in the year. The specific topics covered are the following: Development of filtered neutron beams, Investigation of average characteristics of nuclei in the unresolved energy region, Nuclear structure, Nuclear data for applications, Neutron beam utilization for applications, Nuclear analytical techniques and Sedimentology.

Part A "*Research Activities*" was written by the head of sectors where the work was done. Scientific contracts that are being carried out at the Nuclear Physics Department are given in Part B "*Scientific Contracts*". Part C "*Scientific Reports and Publications*" contains abstracts of reports or publications that were printed somewhere in the year. Part D "*Personnel*" describes the organization scheme of the Nuclear Physics Department.

Dalat, Feb. 1997 . Vuong Huu Tan, Ph.D.
Director,
Nuclear Physics Dept.

3

CONTENTS

A. RESEARCH ACTIVITIES

A.1. NUCLEAR DATA SECTOR

The main activity of Nuclear Data Sector is to carry out nuclear data calculations and measurements, and development of applied researches using filtered neutron beams at the reactor. Some research results before October 1995 have been given in the IAEA report INDC(VN)-007. In this report we present new results from that time which belong to 4 following research directions:

A.1.1. Investigation of Average Characteristics of Nuclei in the Unresolved Energy Region.

From a nuclear physics theory point of view, keV neutron cross section studies will enable us to study the p-wave strength function, especially if one uses low energy keV neutrons precluding the involvement of higher particle waves. The isomeric ratios of nuclei created in keV-neutron reduced reactions are used to evaluate nuclear density parameters. In this year we measured total neutron cross sections of ^{238}U, ^{56}Fe, ^{27}Al and ^{Nat}Pb and developed a calculated program based on simulation of cross section structure in the unresolved region by Monte-Carlo method with the account of both Porter-Tomas and Wigner distributions and Doppler-broadening in order to analyze transmission data and to evaluate average total neutron cross sections and resonance parameters. Average neutron radiative capture cross sections of ^{238}U measured by ourselves after making necessary corrections are presented in the IAEA report INDC(VN)-008. The GNASH95 code for calculation of cross sections and spectra of nuclear reactions was modified to run on personnel computer PC/AT-486.

A.1.2. Nuclear Structure

Nuclear structure can be investigated by the average resonance capture (ARC) method using filtered quasimonoenergy neutron beams. An in-beam neutron capture gamma ray spectrometer was set up on the outlet of the beam port No.4 of the reactor for this purpose. Energy and efficiency calibrations of the spectrometer were carried out using standard gamma sources and gamma rays from the (n,γ) reaction on Ti-sample. Prompt gamma ray spectra from the (n,γ) reaction on the samples of ^{238}U and ^{55}Mn were recorded with different filtered neutron beams. A program for analyzing gamma spectra was written by ourselves to determine energies and intensities of gamma peaks and compiled with the "Thermal-Neutron Capture Gamma-Rays" library (J.K. Tuli, Brookhaven National Laboratory, NNDC/INT-91/1) to compare prompt gamma spectra at different capture neutron energies with thermal neutron capture gamma ray spectra.

We are developing the γ-γ coincidences method which can be used as a SACP spectrometer (summation of amplitudes of coinciding pulses) to study (n,2γ) reactions to get information on nuclear levels above 2-3 MeV and as a normal γ-γ spectrometer to study low-lying excited states. The γ-γ coincidence spectrometer was tested in the experiment with the ^{60}Co source. Summation and differential spectra were taken, analysis of experimetal data were done to evaluate quality of the SACP spectrometer. Experiments for (n,2γ) reactions on the thermal neutron beam are being prepared for the near future.

A.1.3. Nuclear Data for Applications

It is well known that neutron cross section studies in the keV energy region for fissile, breeding, cooling and shielding materials are important to fast reactor technology because the average kinetic energy of neutrons in fast reactors lies in the keV region. Besides, keV neutron cross section are also of interest to astro-physics for calculating the nuclear abundances of heavy elements. In this year we have carried out measurements of total neutron cross sections of ^{238}U, ^{56}Fe, ^{27}Al, ^{Nat}Pb. Besides, we have also developed a fast cyclic neutron activation technique for measuring astrophysically relevant Maxwellian averaged neutron capture (MAC) cross sections at the 25 keV neutron beam after Fe-filter. The cyclic activation method is the repetition of the irradiation and activity counting procedure of normal activation many times. Especially for nuclei with half lives of only seconds a large number of irradiation and counting cycles is needed. We have made evaluation of optimium times in the cyclic activation method for nuclei with short half lives and arranged testing experiments for some nuclei to verify the experimental equipment of the method. We have also developed the method of measurement of the thermal neutron macroscopic absorption cross section of small samples needed in quantitative interpretation of neutron lifetime logs for oil-gas exploitation.

A.1.4. Neutron Beam Utilization for Applications

Applications such as prompt gamma neutron activation analysis (PGNAA), in-vivo prompt gamma neutron activation analysis (IVPGNAA), neutron radiography (NR), etc are also openned by using reactor filtered neutron beams.

The prompt gamma neutron activation analysis facility consisted of HPGe-90 cc detector operated in the Compton-suppressed mode was set up at the outlet of the beam port No.4 of the reactor using the filtered thermal neutron beam. Analytical experiments were carried out on some kinds of environmental and biological samples. Our analytical results are presented at the 3 Conferences (The 1st Conference on Nuclear Physics and Techniques, Hanoi, Vietnam, 14-15 May, 1996; The 5th Asian Symposium on research Reactors, Taejon, Korea, 29-31 May, 1996 and The 10th Pacific Basin Nuclear Conference, Kobe, Japan, 20-25 Octonber, 1996).

In-vivo prompt gamma neutron activation analysis is a technique used in medical diagnosis. It allows to determine some toxic elements of environment like Cd, Hg, Si,... in the body organs or some elements in the body constitution like Ca, Cl, N, Na, P, O, H,...' We are building the IVPGNAA facility at the Dalat reactor using some kinds of fast filtered neutron beams. In this year we have carried out investigations of the thermal neutron flux distribution from different fast filtered neutron sources in the phantom in order to find neutron sources corresponding to required experiments. In the next years it is necessary to produce human phantom, evaluate analytical sensitivities of some elements in the body organs and radiation doses in given experiments.

In the field of neutron radiography some modification of neutron collimators and evaluation of the neutron radiography facility on the tangential No.3 of the reactor were made. Results of this research direction have been presented at the IAEA Expert Meeting on Evaluation of Country Programmes for Neutron Radiography held at Serpong, Jakarta, Indonesia, 13-17 May, 1996.

A.2. SECTOR OF NUCLEAR ANALYTICAL TECHNIQUES

A.2. SECTOR OF NUCLEAR ANALYTICAL TECHNIQUES

Nuclear analytical techniques have become a powerful instrument for solving problems in the field of environmental monitoring, research and management. The main activities of this Sector are as follows:

* Development of two analytical techniques, instrumental neutron activation analysis (INAA) and X-ray fluorescent analysis (XRFA) to improve the sensitivity, accuracy, precision and efficiency of the methods.

* Application of these techniques to obtain baseline data on the concentration of toxic elements such as Hg, As, Se, Sb, Cu, Cr, ect. and its toxic compounds (MeHg) in environmental objects.

* Investigation of environmental pollution caused by heavy metals and other toxic elements coming from industrial manufactering and economic activities.

A.2.1. Instrumental Neutron Activation Analysis

Conventionally, the Neutron Activation Analysis (NAA) using single- or multi-element standards or reference materials (viz. comparator) has been called a relative method in which the comparator and unknown samples are prepared and irradiated, then counted in similarly conditions. The method has been applied at the Dalat nuclear research reactor since more ten years and evaluated as one of the best nuclear analytical methods at the Dalat Nuclear Research Institute (NRI). Although, the method has now disadvantages in preparation of standards and finding suitable reference materials, etc. It has been used for analysing samples of geological, bio-medical and environmental objects with reliable accuracy.

Now, the NAA laboratory is utilizing equipments including the Dalat nuclear research reactor (TRIGA MARK II, P=500 kW) with neutron flux about 2.5×10^{12} n/cm^2/s at rotary rack and about 5.0×10^{12} n/cm^2/s at cells 13-2 and 7-1 (the cells equipped pneumatic systems for irradiation), the gamma spectrometer with HPGe-70 cc detector coupled to electronic modules (ADC and MCA add-on card) and PC/AT computer. The spectrometer has frequently been calibrated and standardized.

Many elements such as Au, Ag, Fe, Zn, Mn, Sn, W, etc. of about 5,000 geological samples and as Hg, Se, As, etc. of about 1,000 bio-medical and environmental samples have been determined by the NAA method. Additional, an extension of the method has been studied on determination of methylmercury (MeHg) by volatilization technique in which MeHg is selectively separated from inorganic mercury by volatilization in a special tool called microdiffusion convey cell. By the technique, about 200 samples of human head hair and fish have been determined for MeHg. The analytical results have contributed in an IAEA cooperation research program (CRP) on assessment of environmental exposure to mercury in selected human populations by nuclear and other techniques. Besides, the selenium concentration has also been noticed in order to aim at investigating the ratio of methylmercury to selenium. The conclusion about correlation of Se and MeHg derived from the above results is very useful for assessment on environmental pollution relation to human health problem.

The NAA laboratory has also participated in some intercomparison runs organized by external (IAEA, Japan) and internal organizations for analytical quality control. The

9

analytical results of the NAA laboratory have been estimated as acceptable and in some cases as good.

In the period of 1994 and 1996, an important effort in the NAA method at the Nuclear Physics Department (NPD) is the study and application of ko-standardization (ko-NAA) method (De Corte, 1987) aiming at creating an appropriate routine of the method at the Dalat reactor in analysing bio-medical and environmental objects in particular. The ko-NAA method has permitted to determine simultaneously multi-elements without the standards or reference materials and it can be considered as the absolute method. The essential requirements for the ko-NAA method are being carried out step by step. They include the investigation of neutron flux spectrum (parameters α, f, Φ_{th}, Φ_{epi} and Φ_f) at irradiation positions of the Dalat reactor (rotary rack, cells 13-2 and 7-1), the calibration of detection efficiency at various geometry positions of samples related to the HPGe detector, the processing of gamma-ray spectra by writing a sub-program linking to a comprehensive ko software package, the preparation of a nuclear reaction data library and the calculation of elemental concentrations by the 'bare triple-monitor' method. In order to assure analytical quality, the ko-NAA method has been tested for reference materials (IAEA-Soil7, NBS-Orchard leave, BCR-Hair, ...). The results obtained by using the method are in good agreement with certified values (deviation about 2-10%).

In the near future, we are going to plan to study and complete the ko software orientation user-friendly and to improve possibility for the spectrum processing module in poor statistical cases. Also, some of problems should be studied as the calculation of detection limits (Currie, 1968), the correction for true-coincidence effects in determination of peak area, the correction in the cases of complex decay, the correction for burn-up effects. Additional, the ko-NAA method should also be performed for epithermal NAA case (e.g. Cd-cover). Finally, the NAA method in general and the ko-NAA in particular will be applied and challenged for many objects of geological, bio-medical and environmental studies.

A.2.2. X-ray Fluorescence Analysis
A.2.2.1. XRF Facilities:

* Annular excitation sources: Am-241 (130 mCi), Ge-71 produced locally (30 mCi)
* X-ray generator (SIEMENS): 50 kV, 50mA
* Semiconductor detector: Si(Li)-detector, FWHM=180 eV at 5.9 keV; HPGe planar detector, FWHM=180 eV at 5.9 keV.
* PC/AT based spectrometer with AXIL-software.
* System of total reflection X-ray fluorescent (TXRF)

A.2.2.2. Research and service activities:

* Fabrication and routine utilization of Ge-71 annular excitation for XRF analysis of elements ranging from Si to Cu in various samples such as biological, environmental, crude-oil, minerals, alloys, prehistoric samples.
* Research on the determination of the purity gold used as jewelry or as bank reserve. The accuracy of the method attains very high (~0.04% for 24K gold). In cooperation with the Nuclear Electronic Department of NRI, many XRF spectrometer systems have been produced and transferred to the banks and companies in Ho Chi Minh City and Hanoi.

* Development of the total reflection X-ray fluorescent (TXRF) techniques in order to analyze the elements in the liquid samples of various environmental subjects such as top water, lake water, and drinking produces.

A.3. SECTOR FOR APPLICATION OF ISOTOPE TECHNIQUES

Most of activities of the Sector have been related to the use of nuclear techniques in order to study sediment deposition and sediment transport in the environmental systems such as reservoirs, rivers, estuaries and coasts. The complex sedimentation dynamics in rivers, especially, in estuaries and coasts are investigated by tracer technologies. The sediment deposition in lakes and estuaries is estimated by using ^{137}Cs and ^{210}Pb techniques. These techniques provide useful information, both qualitative and quantitative, on siltation and movement of sediment in the area of interest. Results obtained during the implementation of KC.09.06A National Project on "Application of Nuclear Techniques for Studying Sedimentation Dynamics" and IAEA TC Project, VIE/8/007 on "Establishment of Sedimentology Laboratory" for the period of 1991 - 1995 were given in scientific reports of the projects and in some papers which have been published somewhere. In this report we would like to present some works which have been done in 1996.

A.3.1 Preparation of Tracer Materials

In sediment transport studies using tracer technology, sedimentation dynamics can be investigated by observing the movement of tracer materials. The tracer material should therefore behave in the same way with respect to hydrodynamic effects as natural sediments when both are exposed to the same sedimentary or hydraulic transport conditions. Thus the tracer grain size and it's grain density must be as similar as possible to the ones of natural sediments.

For bed-load transport studies, we use specially produced glasses containing a chemical element that can be activated by the (n,γ) reaction. Scandium labeled glass had been successfully manufactured in Vietnam in collaboration between Sedimentology Group (SG) and Dien Quang Lamp Company. To make the tracer material become various the homogeneous Iridium - doped glass was produced by SG with help of an IAEA expert from ANSTO, Australia by the beginning of 1996. This tracer seems preferable to Scandium glass because the gamma energies of ^{192}Ir (0.30Mev, 0.47Mev and 0.61Mev) are lower than those of ^{46}Sc (0.89Mev and 1,12Mev). The composition of Iridium glass {percentage by weight: SiO_2 (47.8); Al_2O_3 (18.8); CaO (16.9); K_2O (5); MgO (6); TiO_2 (6); Ir (0.5)} was designed to ensure that it did not contain any long-lived radioactive elements other than ^{192}Ir. Its density is about 2.56 g/cm^3, similar to the density of natural sand.

Besides making tracer materials for the study of bed-load transport, methods of labelling of fine particles such as fixing ^{198}Au and ^{46}Sc on mud, clay and silt are being studied. The fine particle tracers are going to be used for suspended sediment studies.

A.3.2 Study of Sediment Transport

Radioisotope tracer techniques have proved to be a very efficient tool in studies of bed-load transport at estuaries and coastal areas where hydrological conditions are very

complicated. In the years from 1991 to 1995 many investigations were carried out at Haiphong harbor area in order to study the movement of bottom sediments.

Located 100 km east of Hanoi, on the bank of Red river and with a number of nearby navigable estuaries and waterways, Haiphong is a major port and important industrial harbor in the northern part of Vietnam. Unfortunately, in the last decade the sedimentation in the access channel becomes serious. Even though the annual expenditure of large sums of money on dredging, 10 000 draught weight vessels can not enter or leave the port.

The natural causes acting in the sediment transport are very complicated. Factors to be taken in to account are: wave action; winds; currents of different origins being in various directions; fluctuation of the sea level due to astronomical and meteorological tides, increasing the region of influence of waves and currents in the shore profile and causing the reversal of the current in the estuary; mixing of fresh and salt water in the area. Owing to this complexity, the use of any modelling approach is not suitable, especially in the lack of a reliable database that would result from systematic hydraulic and sedimentary surveys.

To get the information on bed-load transport and channel infill rate in the area where the sedimentation rate was estimated to be highest in the whole access channel, an experiment using ^{46}Sc labelled glass as a tracer element was carried out on the northern side of the channel, between buoys number 10 and 12. In this investigation, a total activity of 4 Ci of ^{46}Sc was used. The movement of the bottom sediment was surveyed for two months. The direction and the rate of bed-load transport as well as thickness of the mobile sedimentary layer in the area of 3 km^2 under the effect of southeast monsoon were determined. Results in detail were given in "Scientific Report of National Project KC.09.06A, 1995" and in "IAEA Report, Project VIE/8/007, 1995". These data help port and navigation channel designers as well as coastal engineering managers to have the right way in maintenance and upgrade of the port and the access channel.

A.3.3 Determination of Sedimentation Rates in Reservoirs and Lakes

^{137}Cs is a major component in the fallout from atmospheric tests of nuclear weapons. This isotope is strongly absorbed on fine particles, particularly clay minerals and silts and as a environmental tracer used for estimation of sediment deposition rates in lakes. The method is being employed for determination of sedimentation rates in Danhim hydroelectric plant's reservoir. Core sampling techniques were developed for the purpose of determination of ^{137}Cs content in sediment profiles. Knowledge of the sediment deposition rates is essential to evaluate the real life-span of this structure and to take measures against siltation if required. Lake sediment can also provide useful information on the movement processes that have occurred in the overlying water column and in the watershed.

B. SCIENTIFIC CONTRACTS

B.1. NUCLEAR DATA SECTOR

1. Neutron Beam Utilization. The Research Contract of Vietnam Atomic Energy Commission for the period 1996-2000.

2. Investigation of Average Characteristics of Nuclei in the Unresolved Energy Regions. The Research Contract of National Program for Basic Research for the period 1996-2000.

3. Applied Neutron Capture Gamma Ray Spectroscopy. The Research Contract of National Program for Basic Research for the period 1996-2000.

4. Development of the Fast Cyclic Activation Technique for Activation Cross Section Measurements of Isotopes With Short Half-Life. The Research Contract of National Program for Basic Research for the period 1996-2000.

B.2. SECTOR OF NUCLEAR ANALYTICAL TECHNIQUES

1. IAEA Research Contract No.6931/RB for the period 1993-1996 on "Determination of Mercury and Methylmercury in Vietnamese Pregnant Woman Hair".

2. Technological Transfer Contract with SJC Company on "Production of the XRF Spectrometer for Analyzing Au-Ag-Cu Alloys"

B.3. SECTOR FOR APPLICATION OF ISOTOPE TECHNIQUES

1. IAEA TC Project on "Study of Sedimentation Rates Using ^{137}Cs and ^{210}Pb Techniques" for the period of 1995 - 1997.

2. National Research Contract on "Study of Lake Dynamics and Sedimentation Rates Using Nuclear Techniques" for the period of 1996 - 2000.

C. SCIENTIFIC REPORTS AND PUBLICATIONS

C.1. NUCLEAR DATA SECTOR

C.1.1. 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.

Vuong Huu Tan, Tokio Fukahori

ABSTRACT: Neutron cross section for ^{56}Fe in the energy region from 1 MeV to 50 MeV were calculated by the newest version of the GNASH code, in which the modification was made with the particles transmission coefficients that can be read from external files or calculated in the program using a version of the optical model code ELIESE. The effects of the model parameters and corrections on the calculated cross sections were analyzed for the case of reactions with 14 MeV neutrons. The calculated cross sections and spectra were compared with the experimental data and JENDL-3.

13

C.1.2. 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

Nguyen Canh Hai, Vuong Huu Tan, Nguyen Huu Thang

ABSTRACT: Thermal neutron macroscopic absorption cross section Σ_a is one of the material neutron diffusion parameters needed in different applications. Knowledge of the Σ_a value for different rocks and brines is an important factor in quantitative interpretation of neutron lifetime logs. The method of measurement of the thermal neutron macroscopic absorption cross section of small samples has been developed at the Dalat Nuclear Research Institute (DNRI) using the thermal column of the reactor. The preliminary experiments for verification of the method have been carried out.

C.1.3. Measurement of Capture Cross Sections for ^{238}U on the Filtered keV-Neutron Beams // The IAEA Report, INDC(VN)-008, Vienna, September 1996.

Vuong Huu Tan, Nguyen Canh Hai, Nguyen Trong Hiep

ABSTRACT: Capture cross sections for the ^{238}U(n,γ) reaction were measured related to that of the ^{197}Au(n,γ) reaction with the filtered keV-neutron beams at the Dalat reactor using the activation method. Radioactivities of samples after irradiation were measured with HPGe detectors (50 mm^2 sensitive area, FWHM=150 eV for ^{55}Fe and 70 cc volume, FWHM=2.5 keV at 1332 keV γ-transition of ^{60}Co). The data obtained by the authors were compared with the evaluations in ENDF/B-VI and JENDL-3 and also with the results from recent experimental works.

C.1.4. 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.

Nguyen Trong Hiep, Vuong Huu Tan, Mai Xuan Trung

ABSTRACT: The neutron capture gamma-ray spectroscopy facility assembled at the Dalat Nuclear Research Reactor using the filtered thermal neutron beam at the piercing channel with a flux of 2×10^7 n/cm^2/s and HPGe-90 cc detector operating in the Compton-suppression mode has been used to enhance the sensitivity of quantitative analysis in environmental monitoring. The paper presents characteristics of the spectrometer and gives some analytical results using this facility.

C.1.5. Status Report of the Program on Neutron Beam Utilization at the Dalat Nuclear Research Reactor // IAEA Report INDC(VN)-009, Vienna, September, 1996.

Vuong Huu Tan

ABSRACT: The themal reactor is an intense source not only of themal 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 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. Information presented is based mainly on the results of the National Research Contract KC-09-08.

C.1.6. 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.

Vuong Huu Tan

ABSTRACT: The experimental neutron beam facility for neutron radiography (NR) on the tangential channel No.3 of the Dalat reactor and the technical characteristics of the NR facility are described. Examples of some neutron radiographs are given to demonstrate the capability of the NR facility. Future plans, needs for equipment, proposed applications in Vietnam and regional collaboration on neutron radiography are discussed in detail.

C.1.7. 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.

Vuong Huu Tan

ABSTRACT: The research reactor IVV-9 of the Dalat Nuclear Research Institute (DNRI) has been operating at its present power level of 500 kW since 1984. It currently represents the strongest neutron source available in Vietnam for research purposes and it is the most effective research reactor among developing countries. The activities of the DNRI in the fields of radioisotopes production, radiochemistry, instrumental neutron activation analysis, environmental monitoring, tracer techniques and reactor physics have been presented in the 9th Pacific Basin Nuclear Conference in Sydney (5/1994). In this paper we present the activities in utilization of horizontal experimental channels of the Dalat reactor for researches and applications such as neutron physics and nuclear data, prompt gamma neutron activation analysis, in-vivo activation analysis, neutron radiography and neutron dosimetry calibration. The emphasis will be made on investigations of nuclear reaction and neutron data with the objective of training scientific and engineering personnel joining the National Atomic Power Program which was determined in the near future.

C.1.8. 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.

Nguyen Trong Hiep, Vuong Huu Tan

ABSTRACT: Prompt gamma neutron activation analysis (PGNAA) technique has been established at the Dalat Nuclear Research Reactor (DNRR) using the Compton-suppressed spectrometer. It has become a useful tool complementary to the existing INAA technique with delayed gamma rays measurement in determining the elemental concentrations of biological and non-biological samples. The technique is especially effective in determining elements such as H, B, C, N, P, Si, Cl, S, Al, Fe, Ti, Ca,. . . required for environmental monitoring. The use of a more intensive filtered thermal neutron beam at the piercing horizontal channel of the reactor has considerably improved the detection limits at sub-ppm concentration levels. Applications of the PGNAA technique for analysis of some elements in biological, environmental, geological samples are presented.

15

C.1.9. The γ-γ Coincedence Spectrometer for Research on Nuclear Structure at DNRI
// Proc. of International Symposium on Instrumetation of Small and Medium Accelerators, Tsukuba, Japan, 11.1996.

Nguyen Nhi Dien, Vuong Huu Tan, Pham Dinh Khang.

ABSTRACT: Single-Ge(Li) neutron capture gamma ray spectrometers usually permit the delineation of individual primary transitions associated with the gamma-ray decay of the capture state populated in thermal- or resonance-neutron capture. However, due to dipole character of primary transitions and the Porter-Thomas fluctuations of partial gamma radiative widths, many low-lying excited states may not be represented in the primary gamma-ray spectrum. Further, if primary gamma-ray population of the ground state is not observed. and/or the neutron-binding energy is not known to sufficient precision, the excitation energies of the low-lying states directly populated may be ambiguous. Besides, in the region of deformed nuclei, intermediate excited states above 2-3 MeV have not been investigated well enough because so far experimental facilities have not had a good resolution to excite individual states in this energy range and in single-Ge(Li) neutron capture gamma ray spectra we have no criteria to identify the primary transitions with energies equal to or less than a half of neutron-binding energy. In this situation, the γ-γ coincidence method based on the multiplicity of the gamma-ray decay pattern from the capture-to-ground states in the (n,γ) reaction is a useful tool for nuclear spectroscopy that allows determination of virtually all low-lying and intermediate levels in the energy region above 2-3 MeV which can not be seen in (d,p) or other charged-particle reactions.

There are various configurations for construction of the γ-γ coincidence spectrometer. Some years ago, when personal computers have been not yet used popularly in experimental physics installation, data associated with the gamma-ray energies are stored in the memory modules in NIM or CAMAC standards. When memory space is full up, data from the memory modules are transffered into computer for storing and processing. At the Dalat Nuclear Research Institute (DNRI), in the framework of the Research Contract on Nuclear Data and Nuclear Structure using filtered neutron beams we are developing the PC-based HPGe-HPGe γ-γ coincidence spectrometer which will be used to investigate decay schemes of radioactive nuclei and of compound states of complex nuclei in the (n,γ) reaction. In our case, personal computer is used for controlling procedure, collecting data directly from ADC and storing into its hard disk. When finishing an experimental cycle, on the PC's memory was stored the database which contains all pairs of γ-γ coincidence data from two HPGe-detectors. From this database we can get different spectra (spectrum of summation of amplitudes of coincidence pulses, differential spectra corresponding to various summation of amplitudes, etc.) by special processing programs.

This paper describes experimental facilities including the filtered thermal neutron beam and the HPGe-HPGe γ-γ spectrometer and gives description of algorithm for deducing different spectra from gamma-gamma coincidence data of radioactive sources and some experimental spectra. Discussion on utilizations of the γ-γ spectrometer in the near future is given.

C.1.10. Neutron Beam Experiments at NRI: *Review and Current Status* // Proc. of the 5th Asian Workshop on Utilization of Research Reactors, Jakarta, Indonesia, 24-27 November, 1996.

Vuong Huu Tan

ABSTRACT: Neutron beam experiments are an important activity of the Nuclear Research Institute (NRI, Dalat). From 1984 the research program on utilization of neutron beams of the reactor was conducted. For these purposes investigations on physical characteristics of the reactor; neutron spectra and fluxes at beam tubes; safety conditions have been carried out. Before 1988 the reactor was mainly used for isotope production and neutron activation analysis. In 1988 the filtered thermal neutron beam at the tangential beam tube using a single crystal silicon filter was extracted for prompt gamma neutron activation analysis (PGNAA), neutron radiography (NR) and transmission experiments (TE). In 1990 quasi-monoenergetic keV neutron beams at the piercing beam tube were extracted using the neutron filter technique for nuclear data measurements and applied research.

In the field of material sciences NRI has set up a group of solid state physics and has received an IAEA project on X-ray diffractometer that has been used effectively for structure research of materials. In order to enlarge neutron beam experiments to material research, a project on small angle neutron scattering has been submitted. We hope that in the framework of the regional cooperation program on utilization of research reactors we can discuss and exchange information and experts to evaluate our reactor condition for setting up the small angle neutron scattering facility.

This paper gives the current status of neutron beam experiments at the Dalat Nuclear Research Reactor (DNRR), and outlooks about our possibility of participation in the regional cooperation program on utilization of research reactors.

C.2. SECTOR OF NUCLEAR ANALYTICAL TECHNIQUES

C.2.1. A New Method for the Determination of Methylmercury by Microdiffusion Technique and NAA on Nuclear Reactor // Journal of Chemistry, T. 34, 1/1996, p.13 (in Vietnamese).

Ho Manh Dung and Le Tat Mua

ABSTRACT: The methylmercury is selectively separated from inorganic mercury by micro diffusion technique in a special tool named convey cell. Methylmercury cyanide formed in the inner part of the convey cell is volatilized at an elevated temperature and trapped on a cysteine paper that is placed in the outer part of the convey cell. The cysteine part is then acidified and irradiated as mercury by neutron activation technique on reactor. The inter-comparison analytical results are also indicated.

17

C.2.2. Mercury Level in Head Hair of Vietnamese // Proceeding of the first National Conference on Nuclear Science and Technology, Hanoi, May 14-15, 1996.

Nguyen Tac Anh, Pham Khac Chi, Ho Manh Dung, Le Tat Mua, Cao Dong Vu

ABSTRACT: The determination of mercury and methylmercury concentration in about 1000 samples of human head hair has been applied for the first time in Vietnam in order to evaluate mercury and methyl mercury exposures in the enviroment at five localities.

Neutron activation analysis including non-destructive and destructive is a main technique to determine mercury (T-Hg) and methylmercury (Me-Hg) and other toxic elements in head hair. The analytical technique has been assessed by the IAEA intercomparison program for analytical quality control.

The obtained results of T-Hg and Me-Hg concentrations have shown that the mercury levels in human head hair depend on geographical, dietary, sex and enviromental pollution factors. In this study hair has been characterized as a biological dosimeter and as one indicator of relationship between environmental pollutants and public heath.

C.2.3. Application of NAA for Determination of Environmental and Human Contamination by Hg and Others in Polluted and Goldmining Areas in Vietnam // Report on the International Workshop, EMC, Serpong, Indonesia, 25-26 Nov. 1996.

Nguyen Tac Anh, Ho Manh Dung, Ngo Quang Huy, Le Tat Mua, Nguyen Mong Sinh   and Cao Dong Vu

ABSTRACT: By nuclear analytical techniques a study of the concentration of toxic elements in human head hair and other environmental samples in polluted areas in Vietnam is presented.

Neutron activation analysis is avery useful method for determination of toxic elements in various biological and environmental samples. At the Nuclear Research Institute of Dalat, this method is being extensively applied to study several subjects such as human hair, foodstuffs, fish, soil, industrial waste atc. in order to evaluate human and environment contamination caused by toxic elements (Hg, As, Cr, Cu, Se,...) and its compounds (methylmercury) in various areas in Vietnam.

The analytical technique has been assessed by the intercomparison program of IAEA for analytical quality control.

Pregnant woman's head hair has been the focus for sample collection in this work. In addition, a special population group (Buddhist monks), a gold miner, goldsmiths and some normal population group have also been selected. The defined population groups are residing in distinct regions representing highland, coastal and industrial localities in Vietnam.

The obtained results of T-Hg, Me-Hg concentrations have shown that the mercury levels in human head hair depend on the following factors:

- Geographical factor: Mercury level of residents living in the North Vietnam (C=0.27+-0.14 ppm) are 8 times lower than in the South (C=2.47+-0.91 ppm).

- Dietary factor: Mercury level of the residents living in the coastal regions (C=3.03+-1.09 ppm) is higher than the value in the highland (C=1.05+-0.15 ppm) and the lowest level of Hg and Me-Hg contents is found in head hair of Buddhist monks who never consume fish and fish products (C=0.55+-0.55 ppm).

- The environmental pollution factor: Mercury level in head hair of residents living near industrial centres (in Ho Chi Minh City C=5.05+-1.29 ppm) is 5 times higher than that in a non-industrial region (in Dalat C=1.05+-0.15 ppm).

It means that the mercury level in Ho Chi Minh City is obviously higher than the coresponding value in non-industrial cities suggested that industrial activities discharge appreciable amount of mercury in the environment.

Furthermore the abnormal high mercury levels in head hair of donor groups of gold miners and goldsmiths have shown that mercury losses during goldmining process in mining fields may contaminate our environment seriously.

In this study head hair has been characterized as a biological dosimeter and as one indicator of relationship between environmental pollutants caused by toxic elements and public heath.

C.2.4. The Study and Application on the ko-Standardization Method of Neutron Activation Analysis at Dalat NRI of Vietnam // Proc. of the 5th Asian Workshop on Utilization of Research Reactors, Jakarta, Indonesia, 24-27 November, 1996.
Ho Manh Dung, Nguyen Tac Anh and Cao Dong Vu
ABSTRACT: The study and application on the ko-standardization method of Neutron Activation Analysis (NAA) at Dalat NRI of Vietnam have been presented sequentially as the essential requirements for the method. The requirements include (i) the irradiation on reactor and the determination of neutron flux spectrum parameters (α, f, Φ_{th}, Φ_{epi} and Φ_f); (ii) the measurement and the calibration for detection efficiency of Ge detector; (iii) the processing of gamma-ray spectra; and (iv) the calculation of elemental concentrations.

C.3. SECTOR FOR APPLICATION OF ISOTOPE TECHNIQUES

C.3.1. Determination of Transport Thickness of the Mobile Sediment Layer Using the Method of Gamma Spectrometry in the Field // Proceeding of the first National Conference on Nuclear Physics and Techniques, Hanoi, May 14-15, 1996.
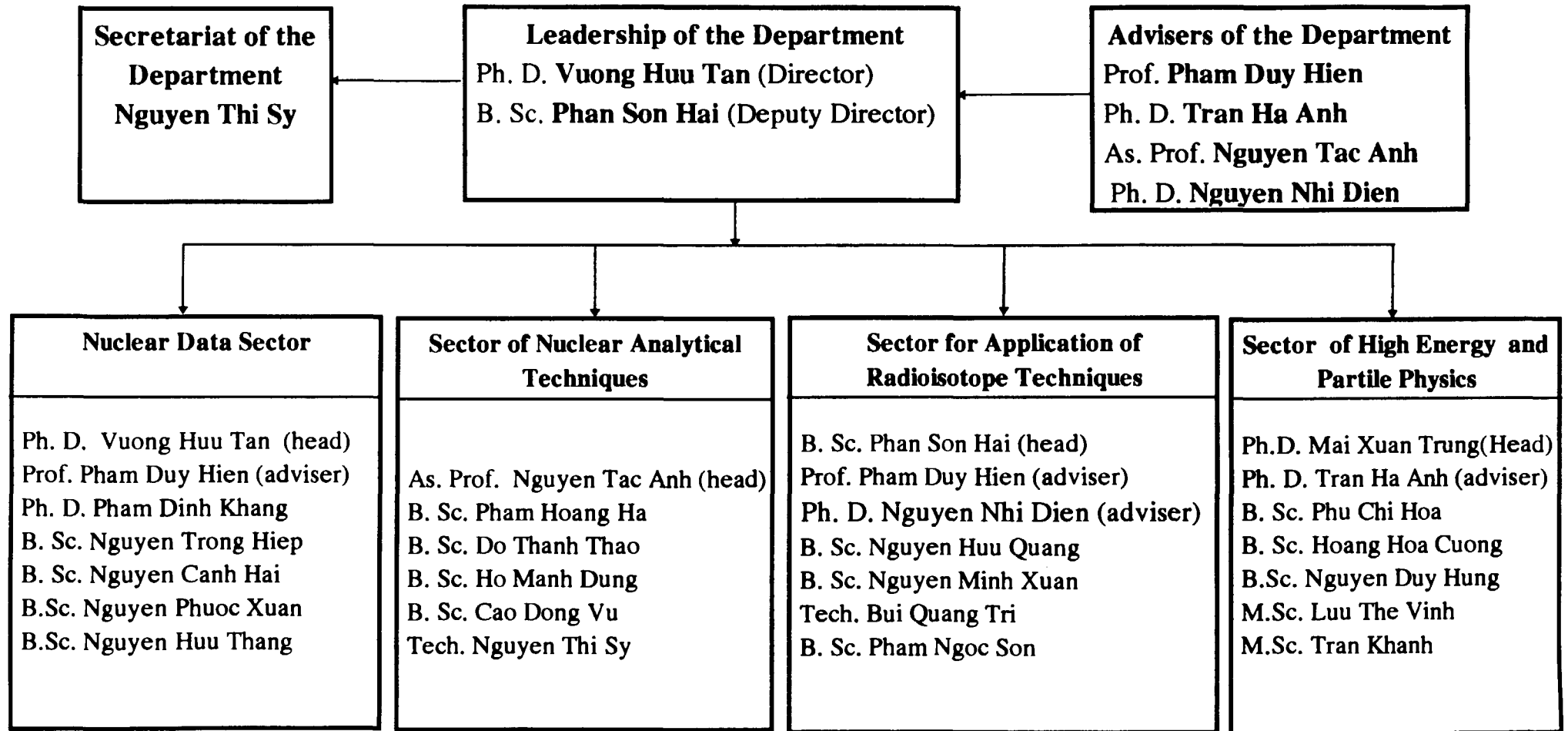Phan Son Hai, Nguyen Huu Quang, Pham Ngoc Chuong
ABSTRACT: The radioactive tracer technology for investigating bed-load transport has now been successfully applied in a wide range of coastal engineering such as the construction or development of major ports, navigation channels, beaches.... However, the quantitative estimate of rates of bed-load transport has been studied for improvement. The new method for determination of transport thickness has been put forward and applied in studying sediment transport at Haiphong Harbour area. Existing approaches are reviewed and their limitations are identified.

C.3.2. Application of the Radioactive Tracer Technique to Study Bed Load Transport at Namtrieu Navigation Channel of Haiphong Harbour // Proceeding of the first National Conference on Nuclear Physics and Techniques, Hanoi, May 14-15, 1996.

N.H. Quang,, P.S. Hai, N.M. Xuan, P.N. Chuong,, P.D. Hien

ABSTRACT: Bed sediment transport study using Scandium glass as tracer was carried out covering the period of 1992-1995 at 4 inspection sites around Namtrieu access channel. The obtained experimental results provide the Port and Shipping channel authorities a firm basis and experimental data for elaborating mechanism, process of the siltation problem at the channel area between Buoy 10 and Buoy 12. The completion of the tracer experiments confirmed the success of development of radiotracer technology in sedimentation study.

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