ACCELERATOR RELATED ACTIVITIES IN VIETNAM

Vo Van Thuan and Tran Thanh Minh, Institute for Nuclear Science and Techniques-VAEC
Nguyen Van Do and Tran Duc Thiep, Institute of Physics-NCNST
Hoang Quoc Viet Street, Nghiado, Hanoi, Vietnam

Abstract

In Vietnam there are several small accelerators working since the 70's in the low energy nuclear physics research and activation analysis. At present, the accelerators are used also in the industry and radiotherapy. For the long term nuclear power program of Vietnam, along with the research nuclear reactor, there is also a need to develop a multipurpose accelerator for manpower training, research, isotope production and other beam applications. The regional cooperation in this field is essential to facilitate successfully such a project.

1 INTRODUCTION

The Dalat research nuclear reactor, commissioned in 1962 and reconstructed in 1982-1984, has been serving as an effective tool for training and R-D in the peaceful uses of nuclear energy. Situation is quite different with the accelerators. Since 1974 a neutron generator (10^{10} n/sec) has been installed at Institute of Physics (IP) in Hanoi for nuclear data study and activation analysis using 14-MeV neutrons. In 1982, a 15-MeV microtron was transferred from the JINR in Dubna to the IP in Hanoi. This machine is still operating today for post-graduate training and research. Heavy targets are used to produce the bremsstrahlung and neutrons for both the basic and applied physics. Neutron and gamma activation analysis method has been developed for the geological and environmental studies. These activities were reported at the APAC'98 [1]. In the Hanoi semi-conductor research institute there is an ion implanter MBP-200 which has been used for training and research in the material sciences or stable isotope analysis. The main technical characteristics of those facilities and their status at present are shown in Table 1.

2 ACCELERATOR BEAMS FOR R-D AND EDUCATION

2.1 Nuclear data with 14-MeV neutron

Since 1980 measurements have been carried out at the neutron generator NA-3C for the 14 MeV neutron induced reaction cross-sections. An IAEA research contract has been accomplished for the measurement and analysis of neutron activation cross-sections around 14 MeV, including (n,2n), (n,p), (n,n'p) or (n,α) cross-sections on Cr, Ti, Mg, Zn, Mo, Zr, Rb and Cr [2]. Since the NA-3C has stopped its operation, the purchase of a new neutron generator is planned in 2002 for the education purposes and the selected activation analysis.

2.2 Isomeric ratio study ($R = \sigma_m/\sigma_g$)

Isomeric ratios were studied at NA-3C in the reaction (n,2n) induced by 14 MeV neutrons and the photo reaction induced by bremsstrahlung (Emax=15MeV) at the microtron MT-17 which lead to both the isomeric (meta stable) state and ground state in the target, with the corresponding cross-sections σ_m and σ_g. These measurements have been performed by T.D. Thiep et al. [3] for ^{142}Nd, ^{144}Sm and ^{110}Pd and T.T.Minh et al. [4] for ^{111}Cd, ^{113}In, ^{115}In, ^{117}Sn, ^{119}Sn and ^{129}Ba.

2.3 Photo-fission

Photo-fission induced by bremsstrahlung (Emax=15MeV) has been studied at the microtron MT-17 with extraction of the known properties of electromagnetic interaction. The mass distribution was measured by cumulative yields of fission products, and the charge distribution was obtained from primary or independent yields of individual fission products. The gamma spectroscopy has been applied to simultaneously measure the yields of many mass chains for different short-lived nuclides. Photo-fission products were identified by determination of their half-lives and energy of gamma transitions. In Refs. [1,5] the mass- and charge distributions of fission fractions of ^{238}U and ^{232}Th were presented. For ^{238}U, 19 independent yields, 62 cumulative yields and 33 mass chains of fission products have been determined using hundred of gamma transitions. For ^{232}Th, 7 independent and 34 cumulative yields as well as 28 mass chains have been obtained in the region of A from 88 to 149. The above-mentioned research program contributed significantly to the post graduate education: up to now dozen students have successfully completed their PhD and Master thesis in nuclear physics after their on-job training at NA-3C and MT-17.

3 RELATED FUNDAMENTAL RESEARCH

3.1 Nuclear physics

In 1996 a Computer Center for Nuclear Science (CCNS) was inaugurated at the INST under support of RIKEN (Japan), which opened a new cooperative program between

Table 1: Existing low energy accelerators in Vietnam

NN	Name	Producer/Year	Type	Beam	Energy	Status
1	Neutron generator NA-3C	Hungary/ 1974	Cockroft-Walton	deuteron	120keV	unused
2	Microtron MT-17	USSR/ 1982	Cyclic-resonator	electron	15 MeV	operating
3	Ion implanter MPB-200	Swizerland / 1979	Cockroft-Walton	ions	150 keV	weakly used

RIKEN and INST. Recently, a nuclear physics group has been established in the CCNS, whose main subject is the nuclear reactions [6,7] induced by heavy ion beams, in particular, the exotic beams produced now at GANIL, RIKEN and other heavy ion accelerator centers in the world. Some application of the effective action method to study the nuclear matter was done in Ref. [8].

3.2 Quantum field theory

Field theory study has been a traditional activity in Vietnam for 30 years. Nowadays, there is a theory group at the IP working on Standard model and beyond (SUSY, 331 models and string, etc.) [9]. Recently, the study of the quark-gluon plasma using the superconductivity theory has become a new trend [10].

3.3 Particle and cosmic ray physics

In Vietnam there was no facility for experimental high energy physics until the recent inauguration of Vietnam Auger Training Laboratory (VATLY) at INST which is an excellent training center for future experimentalists in cosmic ray physics and electronics. VATLY is also expected to join the Pierre Auger international collaboration on searching for highest energy cosmic rays. For this purpose, an exact replica of the Auger water Cherenkov detector has been installed at VATLY under the support of different international collaborations in CERN. Very recently, the atmospheric muon spectrum has been measured in Vietnam for the first time [11]. Some phenomenological study of neutrino oscillation is also being carried out at this laboratory [12]. A group of the Ho Chi Minh-City Branch of the IP, which carries out the research on CP violation in B-physics [13], has recently joined the DØcollaboration at US Fermilab.

4 APPLIED PHYSICS

4.1 Activation analysis

Although the Dalat nuclear reactor is a very powerful tool for the activation analysis, the microtron and neutron generator in Hanoi offer the advantage of high energy neutrons, which are used to analyze some light elements needed for the geological and environmental studies. In particular, the 14 MeV-neutron activation analysis of Al, Si, Fe (in bauxite), N (in soybean) and F (in fluorite ore) has been performed at NA-3C [14]. At MT-17 a combination of bremsstrahlung target (W) and thermal neutron target (^{238}U) was used to develop a combined analysis method based on photo- and thermal neutron activation. Such a mixed photo-neutron activation has significantly improved the sensitivity of the analysis, e.g., for ^{114}Cd, ^{116}Cd and ^{122}Sn, ^{124}Sn, the sensitivity has been improved by the factor from 2 to 10 [15].

4.2 Accelerator technique

The ion implanter MPB-200 has stopped its operation for ten years. In 1992 it was needed to repair this facility for the R-D activity, and the implanter has further served as an useful on-job-training facility on accelerator techniques, such as vacuum, high voltage, electro-magnetic focus, beam monitoring, electronic and mechanical control system etc. The successful reparation [16] has opened an opportunity to carry out a series of research studies at the MPB-200 in the material science and analytical techniques, including stable isotope mass-spectrometry.

4.3 Ion implantation for material science

N^+ or He^+ ions at 50 keV were implanted into steel/Nickel specimens to study the modification of mechanical properties [17]. In particular, the amorphisation was investigated in iron implanted by N^+ ions.

4.4 Stable isotope analysis

The magnetic mass-separator of the MPB-200 at acceleration energy of 50 keV has been tested for mass-spectrometry of light stable isotopes. The result shows a clear resolution of pure natural N-29 (^{14}N + ^{15}N), O-34 (^{16}O + ^{18}O) [16,18] and some estimation of D/H [19]. The accuracy of a few percents is quite suitable for soil-plant relationship research and environmental study [20]. However, that inaccuracy of O-34 and a very significant noise of DH and ^{3}H interference do not yet allow to carry out the isotope hydrology.

4.5 Quality assurance of linac application in the medicine

For the first time, two linacs have been purchased in 2000 by the Hanoi Cancer Institute (K-Hospital) and HCMC Choray General Hospital to carry out the linac radiotherapy. These are variable-energy linacs from 6 to 22 MeV which provide both X-ray and electron beam therapy. The linacs radiotherapy is a new technology in Vietnam and it needs a more accurate training compared to the conventional cobalt tele-therapy. At present, the INST staff is carrying out a technical cooperation IAEA project (VIE/6/021) to enhance the quality assurance of the linac therapy, including training on accelerator technique for the Q-A, maintenance, reparation etc. For this purpose, the INST is maintaining a collaboration with the new Hanoi Cancer Hospital (Thanh Nhan) in a joint center for training on the Q-A of the radiotherapy.

5 ELECTRON BEAM (EB) APPLICATIONS

5.1 Linacs for radiotherapy

The population of Vietnam is around 76.6 million, with the total new cancer patients expected to be about 100.000 per year. In the country there are now about 10 radiotherapy centers equipped with the cobalt tele- and brachy therapies. That is not enough to meet the constantly growing demand. The supply of the first two linacs last year has opened a new era in radiotherapy. For a developing country, such as Vietnam, the cobalt therapy remains very effective. However, a rapid growth of linac therapy is also expected, and one needs a better maintenance and quality assurance which involves the improving knowledge of accelerator technology.

5.2 CT scanners for NDT in industry and inspection

During the last decade the progress of EB accelerator technology has been used to develop large scale CT scanners for non-destructive testing (NDT) not only in the industry, but also in the custom inspection. Vietnam is going to join AFTA soon and the free trade within AFTA would rapidly increase the export-import volume. The accelerator based large sized X-ray CT scanners will be needed to meet the demand of the economical development in the near future.

5.3 EB in the radiation technology

Nowadays, the EB radiation processing was approved widely in commercial scale, such as the cross-linking of polymers in the production of automotive cables and heat-shrinkable package, the preservation of food and sterilization of the medical products. EB may also be used to treat the exhaust gas to avoid acid rain. Those applications are very attractive for the developing countries in Asia-Pacific region. In the ASEAN block, the first EB facilities have been introduced during the last ten years in Malaysia and Indonesia. Vietnam is planning to develop the EB radiation technology for the surface curing, modification of polymer and other applications.

6 TOWARD NATIONAL AND INTERNATIONAL ACCELERATOR CENTERS FOR REGIONAL COOPERATION

A regional cooperation in the application of synchrotron radiation center in Thailand would benefit many. However, the synchrotron ring is more appropriate for the applied physics projects in related disciplines than for the fundamental research in nuclear physics. Due to this reason, some ASEAN countries might be able to join to this collaboration easily. Recently, an INST-VAEC study [21] has shown that Vietnam will need to harmonize the electricity resources in the national energy master plan by reducing the hydropower and increasing the gas combined cycle as well as introducing the nuclear power of 4 GWe by 2015-2017. Such a program would need in about 10 years several new nuclear facilities for manpower training, R-D and the application of radiation and isotopes. Beside the research nuclear reactor, a multipurpose cyclotron would be suitable for this purpose. However, it would be a very big project for a developing country like Vietnam. Therefore, an international collaboration center (located in Hanoi) under a strong support of the developed Asian countries would be highly desirable, which will be useful not only for Vietnam, but also for other ASEAN countries. To further facilitate the high energy physics activities in Asia Pacific region, it should be very attractive for Vietnam to take part in the collaboration at the Linear Collider Project at KEK with possible support from higher developed Asian countries, such as Japan, China and Republics of Korea.

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