



**IOP, VIET NAM**

**Centre of Nuclear Physics  
Institute of Physics**



**VAST**

**RECENT ACCELERATOR BASED NUCLEAR  
PHYSICS RESEARCH ACTIVITY IN VIETNAM**

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15th Meeting of ACFA, 16-17 November 2009, Postech Center Pohang,  
Republic of Korea.

# Talk lay-out

1. Introduction

2. Milestone of the development of nuclear energy  
and nuclear physics in Vietnam

3. Recent accelerator based experimental nuclear  
physics research activity in Vietnam

4. Recent research direction

5. Conclusion

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# The research of Nuclear Physics has been started during sixties years of the last century

In 1974 an accelerator of deuterium, namely neutron generator NA-3-C was put into operation at the Institute of Physics, VAST. It works at an accelerating voltage of 120 KV and produces 14 MeV neutrons via  ${}^3\text{T}(\text{D},\text{n}){}^4\text{He}$  reaction with a flux of  $10^{10}$  n/s



In 1982 another accelerator of electron, namely Microtron MT-17 was installed and started its work at the Institute of Physics, VAST. MT-17 is simultaneous source of 15 MeV bremsstrahlung photons and fission neutron. The average electron beam was 15  $\mu\text{A}$ .

Both the above mentioned accelerators were gifts from the Joint Institute for Nuclear Research, Dubna, Russia and were the only ones by that time in Vietnam.

**Just on the basis of these accelerators the accelerator based Nuclear Physics Research has been started in Vietnam and the research directions were followings:**

### **1. Studies with neutrons:**

1.1. Determination of the reaction cross-section with 14 MeV neutron:

In framework of a coordinated Research Program on “Measurement and analysis of neutron activation cross-sections around 14 MeV” proposed by IAEA.

1.2. Determination of the Isomeric Ratios in 14 MeV neutron reactions

1.3. Neutron Activation Analysis:

- 14 MeV Neutron Activation Analysis using the neutron generator.
- Thermal Neutron Activation Analysis using MT-17

## 2. Studies with bremsstrahlungs in GDR region:

- Photofission.
- Isomeric Ratios.
- Intergrated Cross-section.
- Photon Activation Analysis:
  - ✓ Analysis of protein content in rice and other vegetables.
  - ✓ Mixed gamma-neutron activation for rare earth elements.
  - ✓ Photon Activation Analysis using soft gamma rays.
  - ✓ Photon Activation for Multielement analysis.

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1. On 3 January 2006 “The Strategy on Applications of Atomic Energy for Peaceful Uses up to 2000 year” was approved by the Prime Minister of the Socialist Republic of Vietnam.
2. On 23 July 2007 “ The General Plan for Realisation of the Strategy on Applications of Atomic Energy for peaceful uses up to 2020 year” was approved by the Prime Minister of the Socialist Republic of Vietnam.
3. On 3 Juny 2008 “ The Law of Atomic Energy” was issued by the National Assembly of the Socialist Republic of Vietnam.

## **In these important documents are determined:**

**By the year of 2020 first nuclear power plant will put into operation in Vietnam.**

- To push forward the applications of nuclear energy for peaceful uses.**
- To push forward the fundamental and applied research in Nuclear Physics. Parallely with nuclear reactors, accelerators will be installed.**

**At the present time about ten linear accelerators are under operation for cancer treatment. Soon in the Central Military Hospital 108 was held the Opening ceremony of the Cyclotron Center with Cyclotron Facility of 30 MeV made by IBA Company, Belgium. This cyclotron produces radioactive isotopes for PET and SPECT. There are also two channels for Nuclear Physics Research. It is also planned to install proton accelerator of 250 MeV for ion therapy.**

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- As it is shown above the accelerators NA-3-C and MT-17 are useful for nuclear experimental physics. However they are very limited in energy, particle kind as well as intensity of the accelerated particles.
- Therefore during recent years in order to enlarge the fields of investigations our nuclear physicists have gone abroad to carry out different studies.
- In the conditions of the lack of research facility and budget, we think that one of the best ways to develop accelerator based nuclear physics in Vietnam is to establish international collaborations.
- Up to now we have established collaborations with Joint Institute for Nuclear Research, Dubna, Russia; Pohang Accelerator Laboratory, Republic of Korea; Institute of Nuclear Physics, Orsay, France; RIKEN and Osaka University, Japan.

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## 1. Photofission and Photonuclear Reactions:

( In collaboration with Flerov Laboratory of Nuclear Reactions, JINR Dubna, Russia)

### a. Photofission

In the study of nuclear fission as well as in photofission the most important characteristics are the mass distribution, charge distribution and isomeric ratio of fission fragment. In the past we have concentrated the study on the mass and charge distributions. At the present we have carried out:

- Study of the isomeric ratio in fragment  $^{135}\text{Xe}$  produced in photofission of heavy elements  $^{233}\text{U}$ ,  $^{238}\text{U}$ ,  $^{237}\text{U}$ ,  $^{232}\text{Th}$ ,  $^{243}\text{Am}$  and  $^{248}\text{Cm}$ .

The study of the isomeric ratio allows to obtain important information about the dependence of the level density on angular momentum and probabilities of radiation transitions between the levels. Simultaneously the study on the isomeric ratio in fission fragments allows to discuss about the characteristics of the fission process, in part the role of different kinds of collective movement, affecting on the increasing the angular momentum of fragments at the scission moment of fissioning nuclei.

- Study of rare modes of radioactive decay in fission fragments: delay multineutron, decay of high spin isomeric states of fission fragments.

## b. Photonuclear reaction

- Study of the isomeric ratios in photonuclear reactions in the DGR region. This study furnish valuable information about the energy level structure of nuclei and nuclear reaction mechanism involved. In the case the electromagnetic interaction between photon and nuclei is well known leading to theoretical calculations more simplified. We have investigated different photonuclear reactions as  $(\gamma,n)$ ,  $(\gamma,p)$ ,  $(\gamma,2n)$ ,  $(\gamma,np)$ . The attentions have been paid on the isomeric states with high spin.

c. Monte-Carlo Calculation of Bremsstrahlung Spectra and Neutron Yield for producing intense neutron beam using 100 MeV Electron Linac.

## ***2. Study of Nuclear Spectroscopy and Nuclear Data at Electron Accelerators in the energy range from 15 MeV to 2.5 GeV:***

**( In collaboration with Pohang Accelerator Lab.)**

### **This collaboration initiated by**

- **Prof. Won Namkung, since 2000-present.**

### **Type of collaboration**

- **Vietnamese research group led by Prof. Nguyen van Do (ACFA member: 1998-2004) and Korean colleagues have done common experiments at PAL, and the data processing will be carried out in Hanoi and Pohang.**

### **Fields of study**

- **Study of Isomeric Ratios by Using Bremsstrahlung Photons.**
- **Study of Thermal Neutron Cross-sections and Resonance Integrals by Neutron Activation Method.**
- **Study of Complexity Nuclear Reactions (Spallation, Fission, Fragmentation,..) Induced by High Energy Bremsstrahlung Photons and Neutrons from 2.5 GeV Electron Linac**

### **Main results**

- **Common publications**
- **Education and training young Vietnamese physicists.**

### ***3. Study of the decay of neutron rich nuclei:***

**( In collaboration with INP, Orsay, France in Framework of Project ALTO )**

- **Isotope Separation On-line technique with photo-fission of  $^{238}\text{U}$  by the bremsstrahlung beam produced by interaction between 50 MeV electron beam (from ALTO accelerator) with thick UCx target for production of the very neutron-rich isotopes.**
- **Developing the ion source for ALTO facility.**
- **Studying the decay of very rich-neutron isotopes in vicinity of the  $^{78}\text{Ni}$ .**

#### **4. Study of Charge Exchange Reaction at Accelerator:**

( In collaboration with Research Center for Nuclear Study, Osaka University, Japan )

Charge Exchange reactions of ( $^3\text{He},\text{T}$ ) are being studied .The advantages of this reaction type are that they can be used for accessing GT transitions at higher energies without Q-value limitation, especially when performed at intermediate incident energies above 100 MeV/nucleon and at angles around 0 they can be used as a means to map GT strengths over a wider range of excitation energies.

#### **5. Study of Nuclear Reaction with Heavy Ions:**

( In collaboration with RIKEN, Japan and GANIL, France)

Study of nuclear reactions of astrophysical interest induced by proton rich radioactive beam using international accelerators. Recently, we have performed  $^{21}\text{Na}(\alpha,p)$  reaction using RIKEN AVF accelerator and CRIB spectrometer of Center for Nuclear Study, the University of Tokyo.The data analysis is now in progress.

Have also participated the experiments performed at GANIL for studying transfer (d,p) reactions.

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In conclusion we would like on behalf of the Vietnam Nuclear Society and the Institute of Physics, VAST to express our sincere thanks for the precious support and assistance from the countries-members of ACFA and the collaborated institutions: Joint Institute for Nuclear Research Dubna, Russia; Pohang Accelerator Laboratory, Pohang, Korea; Institute of Nuclear Physics ORSAY, France; RIKEN and Osaka University. We do hope that in the near future more and more collaborations between us will be established for the development of accelerator based Nuclear Physics research.

The special thanks are addressed to Prof. Won Namkung, who initiated the collaboration between the Pohang Accelerator Laboratory and the Center of Nuclear Physics, IOP, VAST. We consider PAL as permanent, longterm and effective address of collaboration.

Thank so much Prof. In Soo Ko, Chair of ACFA and POSTECH center for excellent hospitality devoted to the 15 meeting of ACFA members.

The best wishes for health, happiness and success in the fruitful activity to all ACFA members.

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Thank for your attention!

