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Status of Pohang Pulsed Neutron Facility

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Abstract

We present activities and plans at Pohang Neutron Facility, which is the pulsed neutron facility, based on the 70-MeV electron linear accelerator completed on Dec.1997. We have prepared the 15-m time-of-flight path, a Ta-target system, and the Data Acquisition System. Meanwhile we have measured the total cross-sections of Dy and Hf samples at the Research Reactor Institute, Kyoto University and the neutron capture cross-sections of ^{164}Dy isotope at Research Laboratory for Nuclear Reactors, Tokyo Institute of Technology both in Japan. We also were participated the experiment at the 122-m flight path of the IBR-30 pulsed neutron source of Joint Institute of Nuclear Research in Dubna, Russia.

1. Introduction

In order to support the active nuclear power development program and the nuclear R&D application, the Korea Atomic Energy Research Institute (KAERI) decides to establish the nuclear data project [1]. Its main goals are to establish a nuclear data system, to construct the infrastructure for the nuclear data productions and evaluations, and to develop a highly reliable nuclear data system. To build the infrastructure for the nuclear data production, KAERI wants to build an intense pulsed neutron source by utilizing accelerator facility, technology and men-power at the Pohang Accelerator Laboratory (PAL). We proposed the Pohang Neutron Facility (PNF), which consists of a 100-MeV electron linac, a water-cooled Ta target, and at least three different time-of-flight (TOF) paths [2]. The 100-MeV electron linac was designed and constructed based on experiences obtained from construction and operation of the 2-GeV linac at PAL.

We present the status of the pulsed neutron facility, and activities on the nuclear data production.

2. The Status of Pohang Neutron Facility

2.1. Construction of electron linac

We have constructed an electron linac for the various R&D activities of the neutron facility by utilizing the existing components and infrastructures at PAL on December 1997 [3]. The linac consists of a thermionic RF-gun, an alpha magnet, four quadrupole magnets, two SLAC-type accelerating sections, a quadrupole triplet, and a beam-analyzing magnet as shown in Fig. 1. We have used a thermionic RF-gun instead of a triode gun, which is different from the 100-MeV linac for the neutron facility. The RF-gun is a one-cell cavity with a 6-mm-diameter tungsten dispenser cathode. The RF-gun produces electron beams with average current of 300 mA, a pulse length of 6-μs, and about 1-MeV energy [4]. The alpha magnet is used to match the longitudinal acceptance from the gun to the first accelerating section. An electron moves along an ‘α’-shaped trajectory in the alpha magnet, and the bend angle is 278.6°. A high-energy electron has a longer path length than a low-energy electron; thus, the length of the electron beam is neither lengthened nor shortened in the beam transport line from the gun to the first accelerating section. Four quadrupole magnets are used to focus the electron beams in the beam transport line from the gun to the first accelerating section. The quadrupole triplet installed in between the first and the second accelerating sections is used to focus the electron beams during the transport to the experimental beam line at the end of the linac. Three beam-current transformers (BCT) and three beam-profile monitors are installed to monitor the beam quality during the beam operation. The beam-analyzing magnet at the end of the linac has a bending angle of 30 degree and a zero pole-face rotation.

The electron linac is located inside a tunnel beside the PLS 2-GeV linac. The building has three levels: the tunnel in 6 m below ground level, the klystron gallery is on the ground floor, and utilities, including the air-condition and the air handling units, are on the second floor. There is 3-m-thick concrete shield between the tunnel ceiling and the klystron gallery.

After the RF-conditioning of the accelerating structures and the wave-guide network, we performed the beam acceleration test [5]. The maximum RF power from a SLAC 5045 klystron was reached to 45 MW. The RF power fed to the RF-gun was 3 MW. The beam acceleration experiment was performed after any breakdown had disappeared through the RF structures. The bunched electron beam at the alpha magnet was accelerated in the accelerating sections and transported to the end of the linac. The maximum energy is 75 MeV up to now which is still lower than the target value. The measured beam currents at the entrance of the first accelerating structure and at the end of linac are 100 mA and 40 mA, respectively. The length of electron beam pulse is 1.8 μs and the pulse repetition rate is 12 Hz. The measured energy spread is ±1% at minimum. The energy spread was reduced when optimizing the RF phase of the RF-gun and the magnetic field strength of the alpha magnet.

2.2. TOF Facility

The design of the target system is done using the MC simulation codes, EGS4 and MCNP4. The target system, 4.9-cm in diameter and 7.4-cm in length, is composed of ten sheets of Ta plate, and there is 0.15-cm water gap between them, in order to cool the target effectively as shown in Fig. 2 [6]. The estimated flow rate of the cooling water is about 5 liters per minute in order to maintain below 45 ^{o}C. The housing of the target is made of titanium. The conversion ratio obtained from MCNP4 code from a 100-MeV electron to neutrons is 0.032 as seen in Fig. 3. From the Fig. 3, we can see the neutron yield per kW beam power at the target is 2.0×10^{12} n/sec, which is about 2.5% lower than the calculated value based on the Swanson's formula [7].

The pulsed neutron facility based on the electron linac is a useful tool for high-resolution measurement of microscopic neutron cross sections with the TOF method. In the TOF method, the energy resolution of neutrons depends on the TOF path length. Since we have to utilize the space and the infrastructures in the laboratory, TOF paths and experimental halls are placed perpendicular to the electron linac. We constructed a 15-m long TOF path perpendicular to the electron linac as shown in Fig. 4. With this, the test of the Ta-target system and a data acquisition system will be performed.

3. Activities on Nuclear Data Production

Since there was no nuclear data production facility in Korea, there was no activity until the nuclear data project was launched in 1997. Since then, the collaboration group for nuclear data production was organized from several universities in Korea and joined some experiments in the various neutron facilities in the world. We have measured the capture cross-sections [8] and the total cross-sections [9] of natural Dy and Hf samples in the energy region from 0.003 eV to 50 keV (100 keV) by using the neutron TOF method at the 46 MeV electron linear accelerator of the Research Reactor Institute, Kyoto University. We also have measured the capture cross sections for ^{232}Th [10] at the 122-m flight path of the IBR-30 pulsed neutron source of Joint Institute of Nuclear Research (JINR) in Dubna, Russia. The capture cross-sections of ^{164}Dy isotope [11] was measured by using pulsed neutrons provided from the 3.2 MV Pelletron Accelerator of the Research Laboratory for Nuclear Reactors at the Tokyo Institute of Technology. We have planed to measure the capture cross sections for ^{162}Dy and ^{164}Dy isotope samples at KURRI in this year. There is also a discussion with Prof. M. Baba to join an experiment at the Tohoku University 4.5 MV Dynamitron facility in this year in order to get experiences.

As explained on the previous section, they have completed to construct a 15-m TOF facility at PAL. After checking the radiation level around the TOF facility and the linac, they would like to measure the angular distributions and energy spectra of photoneutrons from Ta-target system with the activation method and the TOF method. From the next year, they would like to measure total cross-sections for the well-known samples with TOF method.

4. Summary and Discussion

The nuclear data project was launched by KAERI from 1996 in order to support nuclear R&D activities, medical and industrial applications. We have constructed and tested a test-linac for the pulsed neutron facility by utilizing the existing components and infrastructures at PAL. The characteristics of accelerated electron beams are about 75 MeV of energy, 12 Hz of repetition rate, 1.8 μs of pulse width and about 40 mA of peak current. We made a 15-m TOF path perpendicular to the test-linac in order to test a Ta-target system and a data acquisition system.

We have joined two facilities to get experiences for cross section measurements at KURRI in Japan and at JINR in Russia. In these facilities, we have measured the capture and the transmission cross sections for various samples. There are also several activities for data evaluations at KAERI with international collaborators.

The workshop for nuclear data production and evaluation was held on August 7 and 8, 1998 and Aug. 19 and 20, 1999 at PAL. The aim of the workshop was to review recent progress, exchange ideas and search future directions in the nuclear data production and evaluation. During these workshops, we discussed various subjects on the nuclear data production and evaluation.

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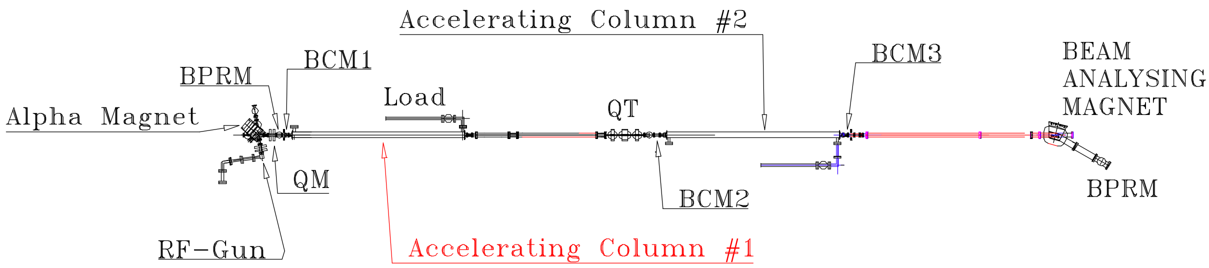
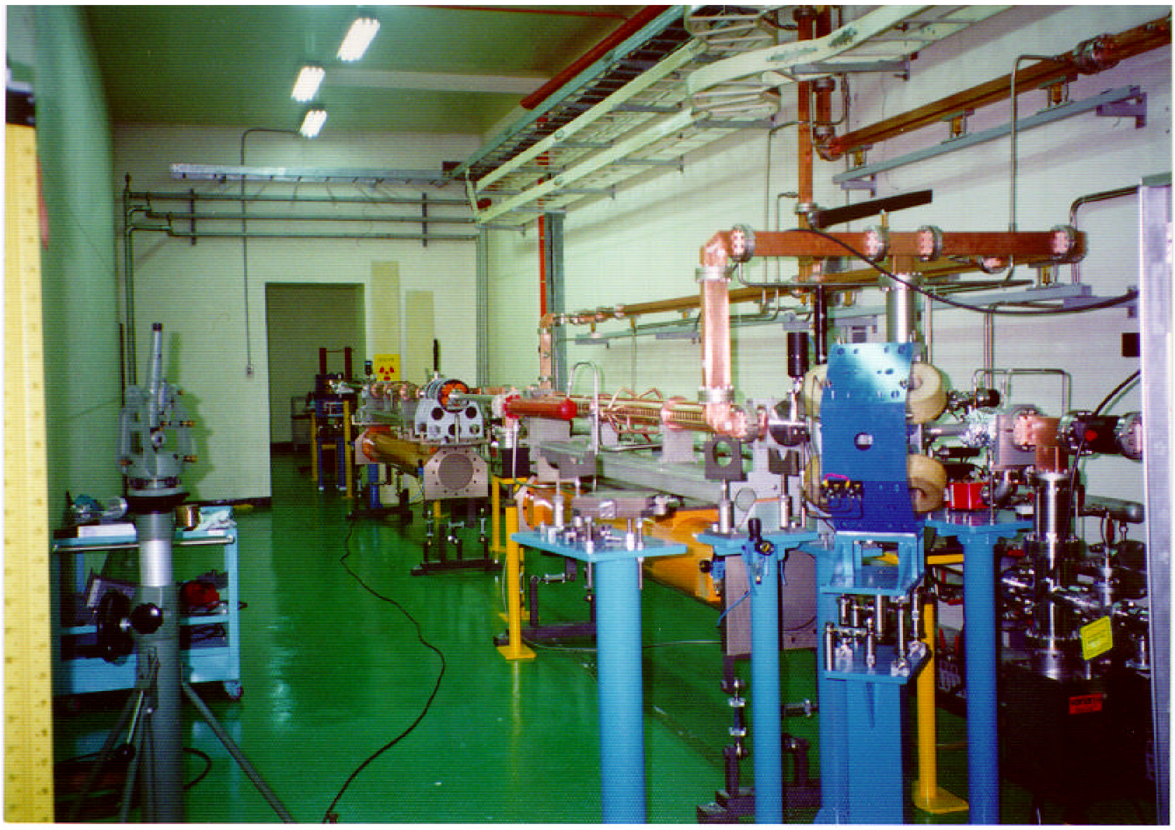
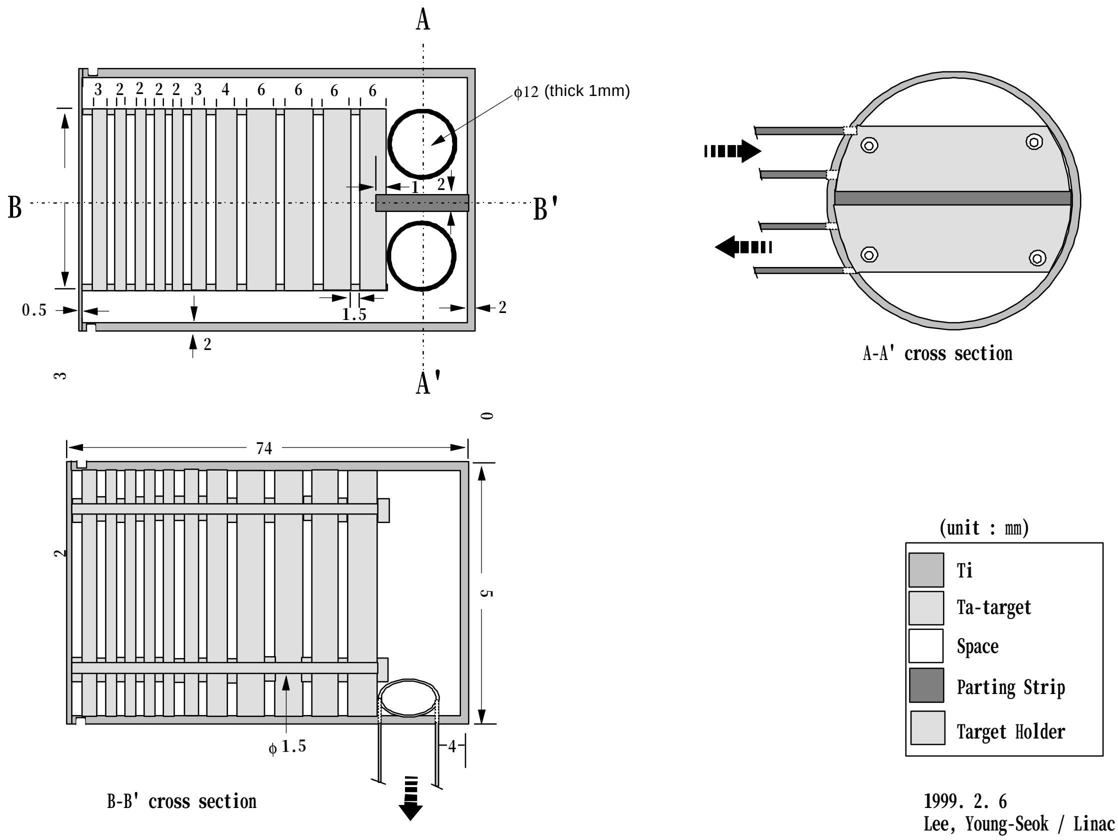


(a)



(b)

Fig. 1. (a) Design of the electron acceleractor, (b) Picture of constructed electron acceleractor



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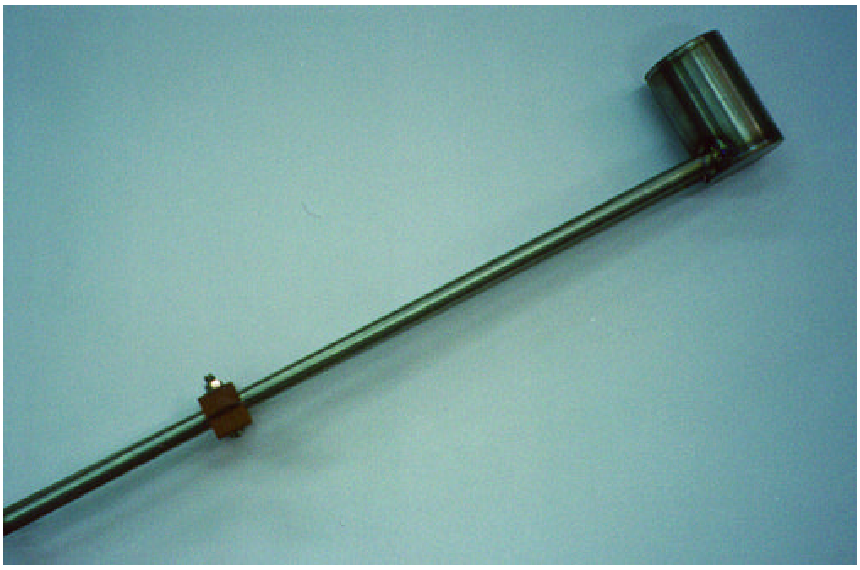

(b)

Fig. 2. (a) Design of Ta-target system, (b) Picture of constructed Ta-target system

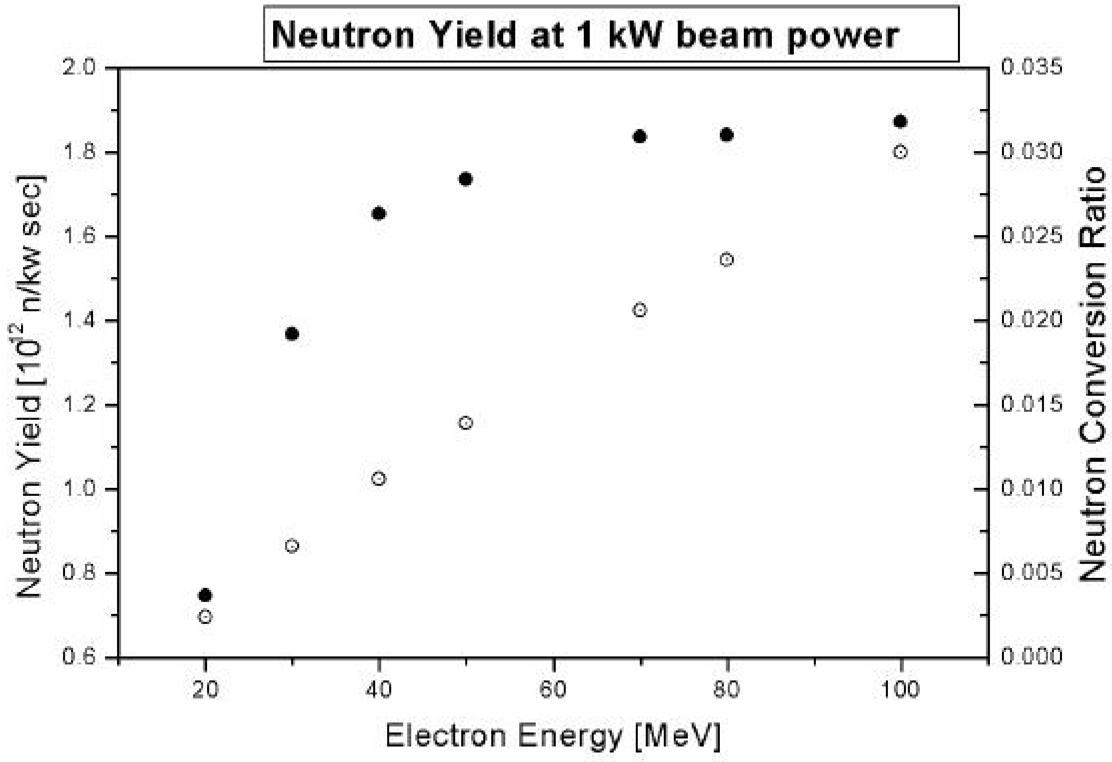

Fig. 3. Calculated neutron yield at 1 kW beam power and the conversion ratio from one electron to neutrons as a function of electron energy.

Fig. 4. Picture of constructed TOF facility