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Concept of a TOF Neutron Source for Nuclear Data Measurement Based on KAERI Electron Accelerator

T. Y. Song *, S. H. Park, B. C. Lee, Y. O. Lee
Korea Atomic Energy Research Institute, 1045 Daedeok-daero, Yuseong, Daejeon, 305-353, Korea
**Corresponding author: tysong@kaeri.re.kr*

1. Introduction

Nuclear data is essential in developing technologies and facilities related to nuclear physics and engineering. The nuclear data can be obtained by performing experiments or evaluation based on experimental data and some theory. Therefore, nuclear experimental data can be the basis of many areas of nuclear engineering. Although nuclear data experiments have been performed for long time, the updated data are still being requested and will be requested in many areas such as medical application, ion beam analysis, nuclear astrophysics, nuclear safeguards, radiation shielding, critical reactors and accelerator-driven subcritical reactors [1].

There are different types of nuclear data according to the particle types of initiating nuclear reactions. Nuclear data related to neutron induced reactions are most important since it can be used in developing nuclear reactors. In the past, experiments were focused on nuclear data of thermal neutron reactions. Now, nuclear data of fast neutron reactions is also of interest since fast reactors are being developed and will be constructed throughout the world in the near future [2].

KAERI has been working on nuclear data evaluation only until now. KAERI plans to develop a TOF neutron source to perform nuclear data experiments of fast neutron reactions. The KAERI neutron source is based on the 20 MeV electron accelerator and a liquid Pb target. In this paper, the concept of KAERI neutron source will be described.

2. Methods and Results

In this section, the concept and characteristics of the KAERI neutron source are described. The general characteristics of neutron sources is described first. Then the KAERI neutron source based on the 20 MeV electron accelerator will be described.

2.1 Neutron Sources

Many different types of neutron sources are available including research reactors and accelerator-based sources. But most of neutron sources are based on the accelerators [3]. The accelerator types are divided into two groups. One is electron accelerators and the other is proton/ion accelerators.

Proton/ion accelerator neutron sources consist of 3 types. The first one is the monoenergetic neutron sources. They can produce neutrons with energy from a few keV to 20 MeV. The second is the proton and deuteron induced neutron sources. They produce neutrons with energy greater than 10 MeV. The third is the spallation neutron sources. The spallation neutron source is the white spectrum neutron source.

The electron accelerator based neutron source utilizes photons produced by bombarding a few tens MeV electrons into materials of heavy mass nuclei. The produced neutrons show white energy spectrum with maximum energy of about 10 MeV.

2.2 KAERI Neutron Source

KAERI has a plan to develop a neutron source by using KAERI’s 20 MeV electron accelerator. The neutron source will be mainly used for nuclear data measurements based on time-of-flight experiments. Currently, a feasibility study is under way.

Since KAERI’s superconducting electron accelerator produces pulse electron beams with a fixed pulse width (~20 ps) and pulse current (~ 20A), the pulse frequency should be large to utilize a large beam power. Once a pulse frequency is fixed, we can calculate a neutron energy of which time-of-flight corresponds to the pulse interval. If neutron energy is lower than that energy, those neutrons are overlapped with the neutrons belonging to the next pulse. Therefore, we can only use neutrons having energy greater than the specific value. We investigated the characteristics of the neutrons based on the neutron source of ELBE [4]. We consider adopting 0.5 MHz frequency. Then neutrons with energy greater than 20 keV can be used for experiments [4].

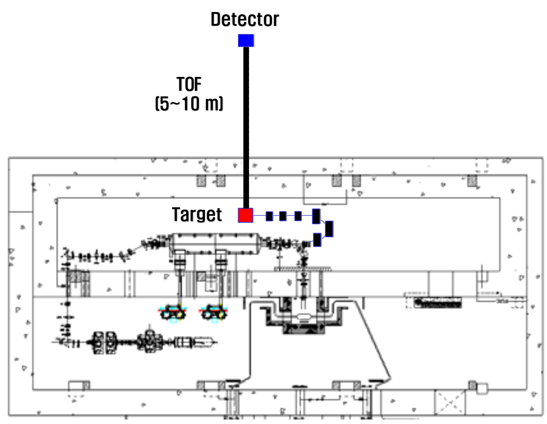

Fig. 1. Plan to install a neutron source target and time-of flight measurement system

When the frequency is 0.5 MHz, the available beam power is approximately 4 kW, which is 25% of the maximum beam power of the KAERI electron accelerator. The estimated neutron production rate is ~2 x 10^{12} n/s with 4 kW beam power and Pb target.

Since the pulse width is ~20 ps, a neutron energy resolution less than a few % can be achieved with a relatively short flight path length like 5 to 10 m [5]. Since a excellent time resolution is required and fast neutrons are used, a liquid metal target is needed. A liquid metal target dose not need water coolant unlike a solid target. Instead, a liquid metal is circulated through inside a closed loop and the dissipated heat is transferred through a secondary cooling loop. Liquid lead is considered as a target material [5].

Table 1. Possible specifications of KAERI neutron source

Beam Energy	20 MeV
Pulse Width	~ 20 ps
Pulse Current	~ 20 A
Pulse Frequency	~ 0.5 MHz
Beam Power	~ 4 kW
Target	Lead
Flight Path Length	5 ~ 10 m
Neutron Production Rate	~ 2x10^{12} n/s
Available Neutron Energy	> ~ 20 keV

3. Conclusions

Nuclear experimental data can be the basis of many areas of nuclear engineering. KAERI has a plan to develop a neutron source by using KAERI's 20 MeV electron accelerator. The neutron source will be mainly used for nuclear data measurements based on time-of-flight experiments. Currently, a feasibility study is under way.

Since a excellent time resolution is required and fast neutrons are used, a liquid metal target is needed. KAERI's superconducting electron accelerator produces pulse electron beams with a fixed pulse width (~20 ps) and pulse current (~ 20A). When the frequency is 0.5 MHz, the available beam power is approximately 4 kW, which is 25% of the maximum beam power of the KAERI electron accelerator. The estimated neutron production rate is ~2 x 10^{12} n/s with 4 kW beam power and the Pb target. Neutrons with energy greater than 20 keV can be used for experiments.

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