Simulations of Cold Neutron Activation Station using MCNPX code

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1. Introduction

In order to enhance the utilization capacity of the HANARO (KAERI) research reactor, a cold neutron facility has been constructed since 2003 and finished in 2009. It has total seven neuron beam guides and two guides of them, CG1 and CG2B, are used for Cold Neutron Activation Station (CONAS).

At present, Cold Neutron Depth Profiling (CN-NDP) and Prompt Gamma Activation Analysis (CN-PGAA) facilities of the CONAS project consists have been underway installed since May 2010. In this study, the simulations of the CONAS are proceeded by using MCNPX code based on the previous studies [1, 2] which contain the predicted results of neutron flux at the end position of the CG1 and CG2B guides and the designed geometry model of the CONAS. From these results of the MCNPX simulation, we can estimate some preliminary results of the CONAS performance and optimize the setup parameters for the main instruments of the CONAS.

2. Simulation method

The experimental specifications of CONAS instruments were depicted in detail of previous studies [1, 2]. Figure 1 illustrates the CN-NDP and CN-PGAA models in the MCNPX simulations in Ref. [1, 2]. Based on these specifications and the CONAS geometry model, the new version (2.7) of MCNPX [3] was adopted for simulating the CONAS.

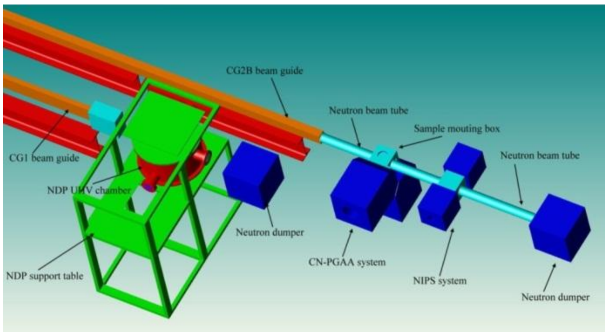

Fig. 1 The assembly components model of the CONAS.

In the new version of the MCNPX code, some advanced features such as the pulse height tally with anti-coincidence option, the mesh tally, speech up lattice, variance reduction and, especially, the neutron-induced prompt and delays gamma-ray were developed [4]. With these useful functions, the MCNPX is suitable for producing valid results and solving the problems investigated in this study. Almost material components and densities used in this study are obtained from the typical handbook values of Compendium of Material Composition Data for Radiation Transport Modeling [5].

3. Simulation Results

3.1 Simulation of the CN-NDP facility.

In NDP technique, the energy spectra of charge particles reflect concentration and depth distribution of the element. In the MCNPX simulation, NIST High-Boron Borosilicate (SRM 93a) sample is placed at the center of UHV chamber with a 450 angle to the z-axis (altitude) for the incident neutron beam, and a silicon photodiode detector faces confronting the sample. The MCNPX energy alpha spectrum tally is shown in Figure 2.

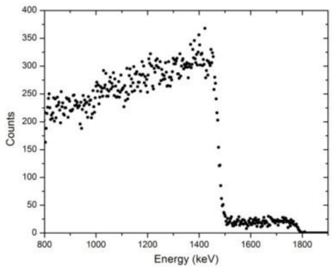

Fig. 2 The simulated alpha energy spectrum of SRM 93a.

3.2 Simulation of the neutron-induced prompt gamma-rays spectra.

The neutron-induced prompt gamma-rays spectra were simulated. The NIST San Joaquin Soil (SRM 2709a) sample was placed at the center inside the Teflon sample mounting box with distance to n-type HPGe detector windows as 27 cm. Figure 3 presents the neutron-induce prompt gamma-rays spectra of the SRM 2709a sample in normal and anti-coincidence mode.

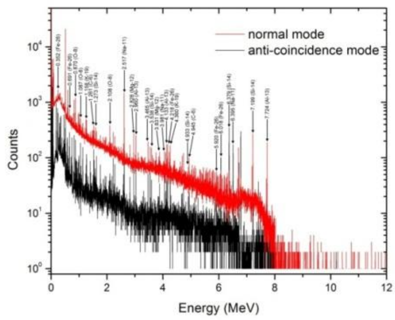

Fig. 3 The simulated neutron-induce prompt gamma-rays spectra of the SRM 2709a sample in normal and anti-coincidence mode.

3.3 Simulated efficiency of an n-type HPGe detector.

The simulated efficiencies of n-type HPGe detectors are performed in the wide energy range from 0.06 to 11 MeV. In this simulation, the radioactive source was placed at the center of sample mounting box with the distance to the n-type HPGe detector windows as 27 cm. Simulated absolute full peak efficiency curves for the n-type HPGe detectors are shown in figure 4.

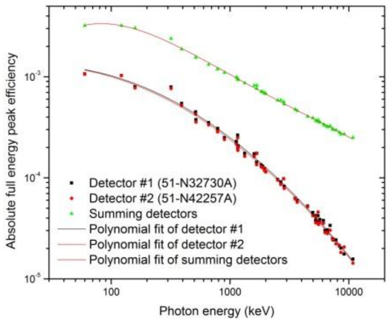

Fig. 4 Simulated absolute full peak efficiency curves for n-type HPGe detectors in normal mode.

3.4 Simulated gamma-ray background spectrum at the CONAS station.

According to the study of Tsutsumi [6], the indoor background source was assumed to be a spherical layer with a homogeneous radionuclide distribution to save the computing time with a slightly discrepancy with the actual bunker shape. In this simulation, a spherical with 200 cm diameter and 40 cm thickness was sampled as indoor background source. The simulated background spectrum from indoor background source normal mode is shown in figure 5.

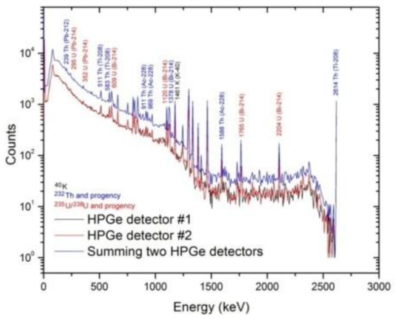

Fig. 5 The simulated background gamma-rays spectrum from indoor background source normal mode.

In the simulation of the beam-background, the CG2B neutron source operated with the presence of D_2O scattering sample and the beam-background come from the continuous activation and excitation of the surrounding shielding and structural materials, etc. as shown in figure 6.

3.5 Estimation the neutron flux at the sample position of CN-PGAA and CN-NDP

Table 1 shows the neutron flux values at the sample position of the CN-PGAA and CN-NDP.

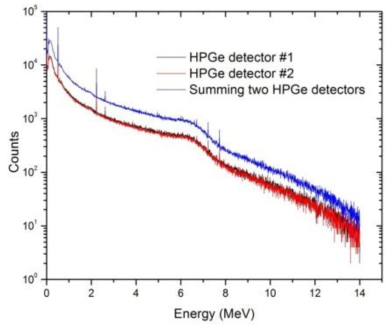

Fig. 6 The simulated background gamma-rays spectrum from beam-background source in normal mode with D_2O sample.

Table 1. The neutron flux values for sample positions.

Sample position	Neutron flux ($n.cm^{-2}.s^{-1}$)
CN-NDP	1.72×10^8
CN-PGAA	9.57×10^7

4. Conclusions

The MCNPX code was used to simulate the CN-NDP system. The preliminary alpha energy spectrum of High-Boron Borosilicate (SRM 93a) sample was simulated considering the hardware specification of the CN-NDP system in CONAS. The simulated alpha energy spectrum is useful for energy calibration of NDP.

The MCNPX simulation with CN-PGAA have done as simulated efficiency, predict neutron flux at analytical sample position, simulation of the neutron-induced prompt gamma-ray spectra with the San Joaquin Soil (SRM 2709a) samples, and simulated the gamma-ray background spectrum of CN-PGAA system in the CONAS bunker.

Acknowledgements

This work was supported by the National Research Foundation of Korea (NRF) grant funded by the Korea government (MEST).

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