Analysis of Induced-radioactivity using DCHAIN-SP for Heavy Nuclei at a Mercury Target Irradiated by 2.8 and 24 GeV Protons.

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Radioactivity estimation in spallation neutron field including incident high-energy protons is essential for designing spallation neutron target and accelerator driven nuclear transmutation system. In particular, the estimation for heavy material such as mercury, lead and bismuth is important since those elements are used as target materials. However, the radioactivity estimation for such heavy material has not been easy and reliable, because the products cover wide range of nuclei, consideration of huge kinds of reaction paths is required, and the most of reaction cross sections for high energy incident particles are unknown or unreliable.

A radioactivity calculation code consisting PHITS, MCNP4C and DCHAIN-SP 2001 has been used for the radioactivity estimation for design of the J-PARC facilities. In this work, we validate the code system for mercury, lead and bismuth samples by the experimental activation data obtained using AGS (Alternative Gradient Synchrotrons) accelerator at Brookhaven National Laboratory.

In the experiment, the samples of mercury-oxide, lead and bismuth were irradiated around the mercury target, which was bombarded with 2.83 and 24 GeV protons. The samples were placed at the top and side of the target. The top samples were irradiated by incident protons in addition to secondary neutrons, and the side samples were mainly irradiated by the spallation neutrons from the target. The number of protons injected to each top sample were determined by the foil activation method using the reference reaction of Cu(p, x)^{24}Na. The total incident protons were measured by an integrating current transformer (ICT) and separated electron chamber (SEC). The neutron flux at the side samples were validated using ^{93}Nb(n, 2n)^{92m}Nb reaction. After the irradiation, the radioactivities of samples were measured with HPGe detectors at the cooling time between 2 h and 267 d. The detail of the experimental procedure and the experimental data were shown in the reference [1]. The calculation procedure using the calculation code system is described in the abstract of this symposium [2].

As the results of the comparison between the calculated values and the experimental data, we found that the calculations underestimated the activities by a factor of 2 on the average. We also found that the C/E-values have the dependence on mass numbers of products, which implies that the calculated mass yield curve for spallation reactions shows different tendency from the real one. We will present the comparison between the calculated mass yield curve and the experimental-basis mass yield curve deduced from the activation data.

References

[1] Y. Kasugai, et. al., "Measurement of Radioactivity induced by GeV-Protons and Spallation Neutrons using AGS Accelerator.", JAERI-Research 2003-034 (2004).

[2] T. Kat, et al., "Analysis of Induced-radioactivity using DCHAIN-SP for Light Nuclei at a Mercury Target Irradiated by 2.8 and 24 GeV Protons", to be presented in this conference.