Vol. 13. (1976)

研究論文

002 *Flux Distributions of 14-MeV Neutrons*

Yoshihide KONDO

(Received Sept. 20, 1976)

Flux distributions available from neutron generators are considerably different from one installation to another. The present paper reports the results of experimental study on flux distributions by counting the positron activity from the $^{63}Cu(n, 2n)^{62}Cu$ reaction induced by 14-MeV neutrons. The experiment is performed using a depleted target in non-uniform tritium loading. Reproducibility and symmetrical property about the flux distributions are examined, and the effective flux distributions are measured.

1. Introduction

Flux distributions available from neutron generators are essential in irradiation experiments on qualitative analysis, helth physics, radiation damage studies, and so on. Experimental measurements on 14-MeV neutron flux distributions have been reported in several papers.[1)-6)]

In general, flux intensity falls off and flux distribtion becomes more symmetric with respect to the target axis as the distance from the target plane and/or the target axis increases. The flux distributions are considerably different due to the following factors: variations in sample target geometry, neutron scatter and absorption, uniformity of tritium loading in the target, depletion of tritium in the target, fluctuation in deuteron beam intensity and wandering of a strongly focused beam over the target. And characteristics of neutron generators and irradiation facilities are different from one another. For the above reasons, the literature does not always indicate the practical flux distributions in our irradiation experiments.

The purpose of our experiments is to examine the flux distributions of 14-MeV neutrons in our irradiation facility. We have tried the experiments, using a depleted tritium target which may cause poor reproducibility of flux distributions in the irradiation experiments. In a previous paper[7)], the flux distributions were measured on the outer surface of the aluminum cooling cap. The present paper reports the spatial distributions of neutron flux in the vicinity of the tritium target.

2. Experimental procedure

2. 1 Sample material

Ninety sheets of circular copper plates (purity: 99.9% up, thickness: 0.5mm, diameter: 10mm, weight: 0.2367±0.0152gr) are prepared as the activation samples. Twenty sheets among these samples are mounted on the sample holder made of acryl plate (thickness:

2mm) in the plane parallel to the target as shown in Fig. 1, and activated. Sample-to-target distances are changed from 2.5 cm to 22.5 cm at intervals of 2.5 cm to measure spatial distributions of 14-MeV neutron flux.

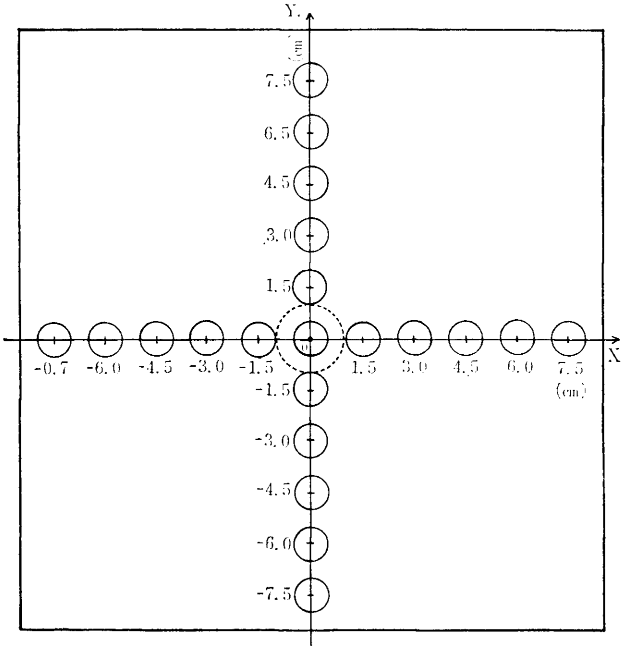

Fig. 1 Arrangement of irradiated samples for 14-MeV neutron flux disribution measurements. These samples are mounted on acryl holder. Solid circle : sample size (1.0cmϕ), dotted circle : effective target size (2.0cmϕ), origin : axis of target.

2. 2 Irradiation

14-MeV netrons are produced by the $^3H(d, n)^4He$ reaction with a Cockroft-Walton type accelerator of Kinki University made by Texas Nuclear Corp. In order to maintain constant beam form and current, all controllable accelerator parameters are kept as constant as possible throughout the experiment. Operating conditions of the accelerator are adjusted as follows— extraction potential : 5 kV, focus size of deuteron beam : ~2 cmϕ, accelerating voltage : 120 kV beam current : 450 μA irradiation time : 10 min. The center of the deuteron beam on the target is set at the target axis by means of induced activity meassurements of four copper plates. The samples are placed on 1.5 cm, −1.5 cm of the axis of X and Y (see Fig. 1) in the plane parallel to the target, at the distance of 2.5 cm from the target plane. If the specific activities are not symmetric with respect to the target axis, the drift tube position is altered until the desired result is obtained.

2. 3 Measurement

The spatial distributions of 14-MeV neutron flux are obtained by counting the positron activity from the $^{63}Cu(n, 2n)^{62}Cu$ reaction induced by 14-MeV neutrons. During a cooling time of 1.5~33.0 minutes, the induced activity from each sample is measured one by one for a minute using the GM tube (MGMA 1210-1, Fuji Electric Co.) , which is coupled to the counting system (SA-250, Fuji Electric Co.), The decay curve shows the presence of ^{62}Cu

(half life : 9.8min, threshold energy : 11.8 MeV, cross section : 540 mb). Possible influence of ^{66}Cu, ^{64}Cu and ^{65}Ni produced from 14-MeV neutron activation is negligible.

The spatial distributions of 14-MeV neutrons are obtained in relative value from counting rates of the individual samples, which are corrected for the differences of sample weight, cooling time and neutron intensity, and converted to specific activities. The flux distributions in relative value are not disturbed by using acryl sample holders. Influence of neutron scatterring by these holders is not detected with measurement on ^{62}Cu activity by the GM countig system.

3. Results and discussion

3. 1 Reproducibility of flux distributions

It is undesirable for the irradiation experiments to use a depleted target in non-uniform tritium loading, which may cause poor reproducibility of flux distributions. So we examine on the reproducibility of flux distributions. Figs. 2 and 3 present the examined reproducibility of rerative flux at various positions from the target axis and from the target plane, respectively. Standard deviation for each measuring point is drawn in Figs. 2 ~ 7. Data used for Figs. 2 and 3 are measured during several days. Neverteleless, considerably reproducible results are obtained, which may be due to wide spot of beam focus used.

3. 2 Symmetrical property of flux distributions

In the irradiation experiments using a deplepleted target, the flux distributios may show asymmetry with respect to the target axis, which are examined in this experiment. Figs. 4 and 5 show the examined symmetrical property of relative flux at various positions from the target axis and from the target plane, respectively. Fairly symmetrical results are obtained as shown in Figs. 4 and 5.

3. 3 Flux distributions of 14-MeV neutrons

Figs. 6 and 7 present relatve flux at various positions from the target axis and from the target plane, respectively. In the expriment, the reproducible flux distributions are obtained in symmetrical patterns with respect to the target axis. Special attention should be paid to strong flux gradients in the case of irradiation on bulk samples. Since the flux intensity becomes higher as the distance decreases from the target plane and the target axis.

The results of measurements on the present experimental flux distributions of 14-MeV neutrons are the useful basic data for practical use of the accelerator.

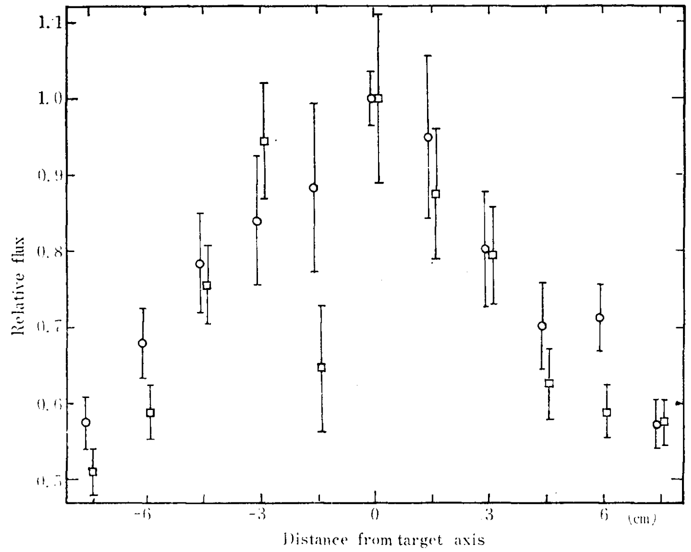

Fig. 2 Examined reproducibcility of relative flux for various distances from the target axis, at a distance of 10cm from the taxget plane.

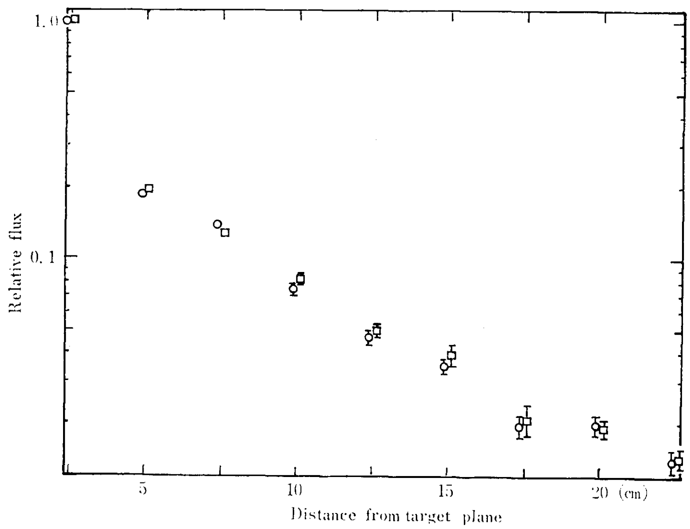

Fig. 3 Examined reproducibility of ralative flux for various distances from the target plane, along the target axis.

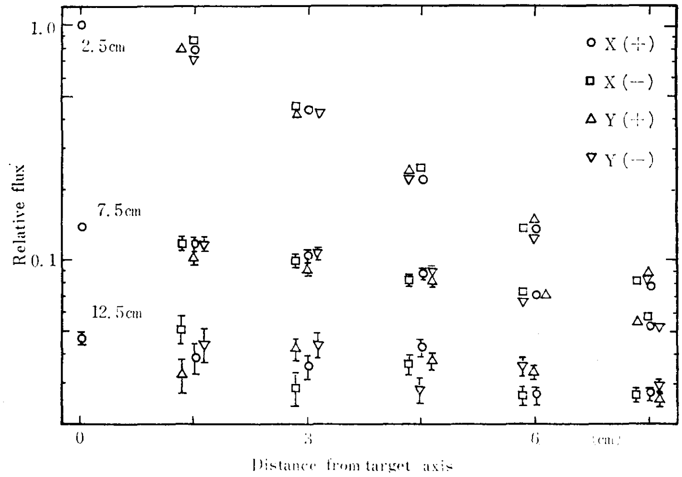

Fig. 4 Examined symmetrical property of relative flux with respect to the target axis for various distances from the target axis, at distances of 2.5, 7.6 and 12.5cm from target plane.

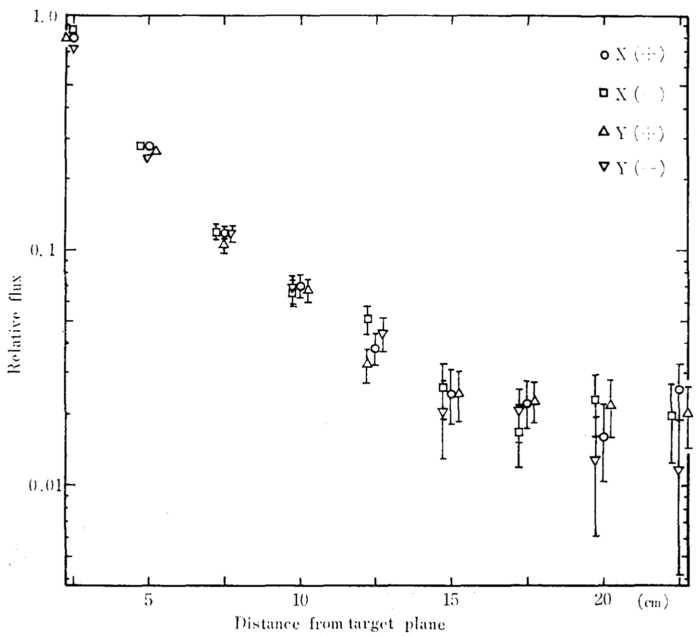

Fig. 5 Examined symmetrical property of relative flux with respect to the target axis for various distances from the target plane, along a distance of 1.5cm from the target axis.

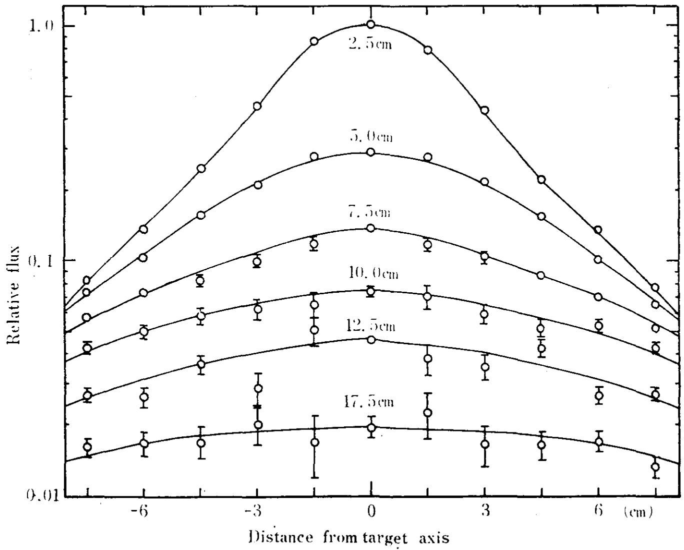

Fig. 6 Relative flux for various distances from the target axis, at distancse of 2.5, 5.0, 7.5, 10.0, 12.5 and 17.5 cm from the target plane.

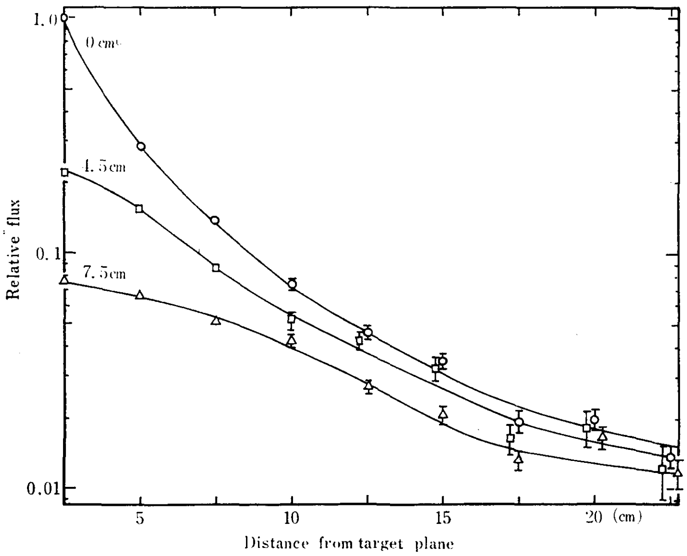

Fig. 7 Relative flux for various distances from the target plane, along distances of 0, 4.5 and 7.5 cm from the target axis.

Vol. 13. (1976)

The auther wourld like to express many thanks for Professor T. Azuma of Osaka Institutute of Technology for his discussions of this paper.

References

1) R. A. Jarjis and S. E. Hunt, Int. J. Appl. Radiat. Isoptopes, **26**, 57 (1975).
2) S. S. Nargolwalla and E. P. Przybylowicz, Activation Analysis with Neutron Generator, Wiley-Interecscience, New York, 1973.
3) R. V. Grieken, A. Speecke and J. Hoste, J. Radioanal. Chem., **10**, 95 (1972).
4) T. Kishikawa and C. Shinomiya, Bull. Chem. Soc. Japan, **43**, 1056 (1970).
5) J. Op de Beeck, J. Radioanal. Chem., **1**, 313 (1968).
6) B. T. Konna and F. J. Conrad, Health Phys., **12**, 56 (1966).
7) Y. Kondo, M. Yamauchi, R. Ariyoahi, N. Endo and R. Miki, Ann. Rept. Kinki Univ. Atom. Ener. Res. Instit., **12**, 21 (1975).