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Secondary Radiation Shielding of Multi-Target Changer

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1. Introduction

The irradiation of high energy ion beam gives rise to many secondary particles from the activation of a target and surrounding materials. When the irradiation of high energy region is required to many samples, it is possible for an experimenter to be exposed to high dose radiation by the radioactive targets. From the safety point of view, auto multi-target changer can be played a role reducing chances that one gets close to irradiated port. But activated targets positioned in the target changer give another radiation effects on each other besides effects of concerned primary beam. This work suggests multi-target changer to be applied at irradiation port of MC-50 cyclotron at KIRAMS and estimates how much the activation effect of a target can be reduced by the multi-target changer.

2. Methods and Results

This section describes the structure of the target changer and presents the simulation results of shielding effect by the target changer.

2.1 The Structure of Multi-Target Changer

There are many cases that small size sample are to be irradiated under various beam conditions at MC-50 cyclotron. Until now, an experimenter repeatedly went in and out irradiation room and that resulted in exposing and amount of dose irradiation on him. An auto-multi target changer is needed to reduce the possibilities of radiation exposure. The target changer designed by this work has four components as follows; loading axis connected moving motors, target holder, target cassette, and lead collimator. Fig 1 shows the schematic diagram of the target changer.

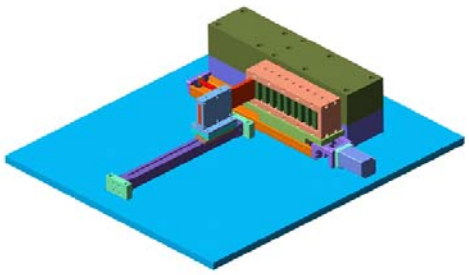

Fig. 1. Conceptual design of multi target changer.

The target changer is driven by a pneumatic mounter and a servo motor. A pneumatic mounter is connected with the rod, which is loading a target holder to irradiation position out of cassette through lead collimator. A servo motor is connected to the cassette and aligns the concerned target holder with the load axis. The cassette has spaces to put ten targets into. There are lead walls between the spaces and the role of the wall is to prevent that radiation emitted from the activated target affects on neighbor targets. The target holder is designed to set a target with diameter less than 4cm. In the case of irradiation, target holder is not located in the path of ion beam. The target to be irradiated by ion beam is positioned at the end of beam line via the lead collimator, which reduces irradiation effect on other targets.

2.2 Simulation of Shielding Effect

The calculation for shielding effect of target changer considered with two points, shielding for surrounding radiation during irradiation and shielding for radiation from the activated targets. Fig 2 shows the model for calculating the dose of target samples in a cassette during irradiating the destinated target. The dose calculation carried out by using the MCNPX code[1]. Supposing irradiation of the 35MeV proton beam, the dose effects on targets in the cassette could be neglected, less than 1E-9 Gy per nA protons.

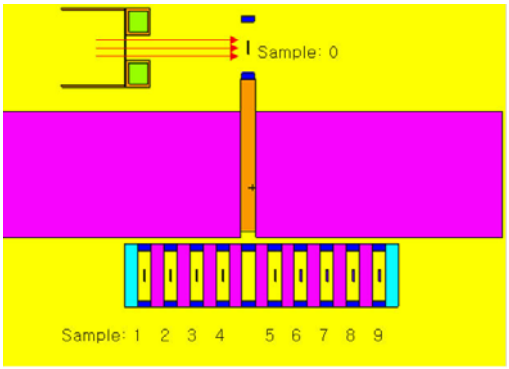

Fig. 2. Modeling for simulation when ion beam irradiates on the target sample.

Fig. 3 shows the model for calculation of effects by an activated target sample. The radiation from the activated target is supposed to be mainly gamma rays. The energies of gamma rays as sources were supposed

as 0.511MeV and 2MeV considering gamma rays tables of 'Table of Isotopes'[2] in which gamma rays from the isotope with lifetime of 1 days longer is almost 99% below 2MeV and 62% below 0.511MeV.

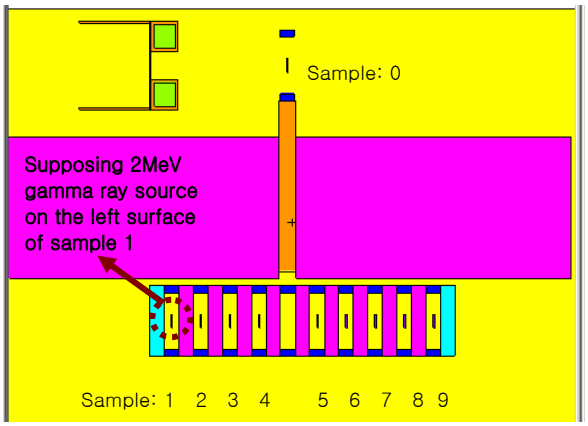

Fig. 3. Model for simulation of effect by activated target sample.

Supposing 2MeV gamma ray source on left surface of the sample 1, self-irradiation dose was 0.4 Gy/Ci and irradiated dose at the closest neighboring sample, sample 2 was hundred times smaller than at sample 1. The dose effect on the sample 9 was million times smaller. Supposing 0.511 gamma rays from sample 1 had no effect on sample 5 further. Fig. 4 shows the shielding effect between the samples. The filled red circle is dose transferred to each samples without shielding wall and the filled black rectangular is with shielding wall. The open blue circle is the ratio of dose with no shield to dose with shield. We can see that the dose of neighbor samples is too smaller than self irradiation dose of sample 1.

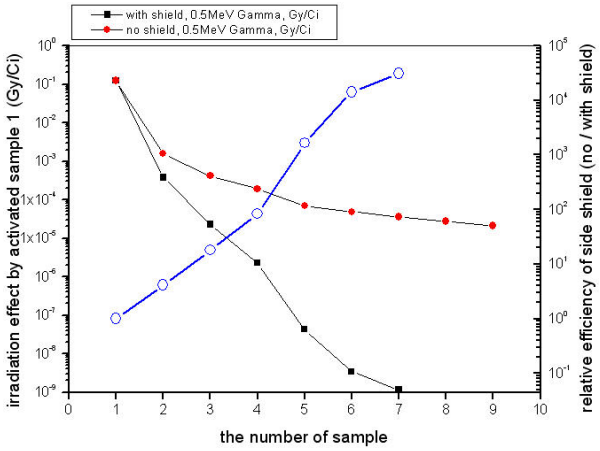

Fig. 4. Dose transferred to each samples with (filled black rectangle) and without shielding (filled red circle).

3. Conclusions

This work is designed for a multi target changer delivering less dose to an experimenter and calculated the shielding effect with two points, indirect irradiation during irradiating the concerned target and irradiation by activated target.

The simulation for shielding effect of the multi target changer showed that samples neighboring to the activated sample got negligible dose comparing to self irradiation dose of it. This result means the designed one is available to use for multi target irradiation.

ACKNOWLEDGEMENTS

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REFERENCES

[1] http://mcnpx.lanl.gov/
[2] Richard B Firestone, Table of Isotopes, Wiley-Interscience, 1996