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Design of the Remote Handling System for Highly Activated Samples by Proton Beam Irradiation

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1. Introduction

A 100-MeV high power proton linear accelerator has been developed by the PEFP (Proton Engineering Frontier Project) is going to be completed by the end of this year. Beam service will be started from 2013 with two target rooms among the ten target rooms. They will be utilized for the experiments in the various application fields. Sample activation can be followed by highly energetic proton beam irradiations for many kinds of sample materials. For the radiation safety of the operator, remote handling facility is necessary. In this paper, we present the design of the facilities conceptually.

2. Methods and Results

MCNPX, PHITS, and DCHAIN codes were used for the calculation of the sample activations. In this section some calculation results are described.

2.1 Operating Conditions

The operating parameters of the two target rooms, TR103 and TR23, are summarized in the Table. 1.

Table 1: Operating Conditions of Target Rooms

	TR103	TR23
Beam Energy [MeV]	100	20
Average Beam Current [mA]	0.3	0.6
Repetition Rate [Hz]	15	30
Pulse Length [ms]	0.1~1.33	0.1~2
Max. Irradiation Area, Diameter [cm]	30cm	30cm
Irradition Condition	Horizontal, External	Horizontal, External

As shown in the Table 1, maximum proton beam powers which can be utilized at the TR103 and TR23 are 30 kW and 12 kW.

Next to the target room, the processing room is located. In the target room, samples will be irradiated by the proton beam, and samples will be pre- and post-processed in the processing room. The layout of two rooms with shielding structure is described in the Fig. 1.

2.2 Sample Activation

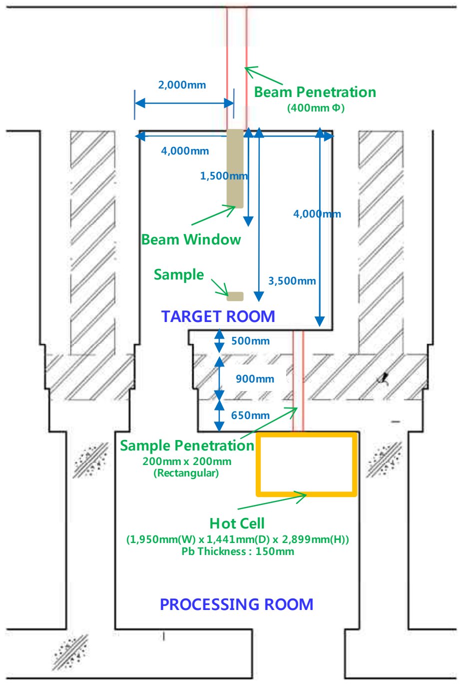

Fig. 1. Layout of the Target Room (TR103) and Processing Room.

The radio-activities of the samples by proton beam irradiations were calculated using PHITS, MCNPX, and DCHAIN-SP codes. The representative samples, such as water, carbon, Aluminum, Silicon, were considered, and some target materials for RI production, such as Cu-67, Sr-82, Ge-68, Pd-103, were also considered. The Gamma dose rates at 10-cm distance from the target surface were also calculated. The calculation results for RI targets are summarized in Table 2. The average current of the proton beam was 1 μA, and the irradiation are is 5 cm in diameter proton beam irradiation to the target area of 5 cm in diameter. The thickness of the target material was supposed to be 1 mm, and the target to be surrounded by the 0.5-mm thick SUS plate.

Table 2: Calculation Results of Sample Activation by 1-μA Proton Beam Irradiation for 1 hour

Isotope	Proton Energy [MeV]	Target	Activity [mCi]		Gamma Dose Rate [mSv/hr]	
			EOB	After 1 hr	EOB	After 1 hr
Cu-67	98	ZnO	294.28	46.12	24.99	3.32
		SUS	53.52	8.91	8.04	1.44
Sr-82	56	RbCl	294.28	46.12	99.48	1.35

		SUS	53.52	8.912	46.18	6.78
Ge-68	35.4	Ga	397.35	124.99	13.02	6.95
		Nd	68.16	4.88	9.13	0.65
Pd-103	20	Rh	8.27	2.38	3.86	0.01
		SUS	12.3	1.22	4.42	0.60

2.3 Hot Cell

To shield the gamma radiation from the activated samples, hot cells will be installed at the processing room next to the target room. The wall thickness of the TR23 and TR103 were decided to 10 cm and 15 cm, respectively. According to the calculation results, the thicknesses were enough to reduce the gamma dose rate below to the 12.5 μSv/hr for the 10~100-μA high current irradiation experiments. For example, Cu-67 if we use 100- μA proton beam, the radioactivity of the target at EOB of 1 hr irradiation will be 34.78 Ci, and the gamma dose rate at the hot cell surface will be 8.8 μSv/hr with 10-cm Pb wall. The drawing of the hot cell is described in the Fig. 2. The inner space of the hot cell is 1482mm (W) x 1345mm (H) x 900mm (D), and two manipulators will be installed.

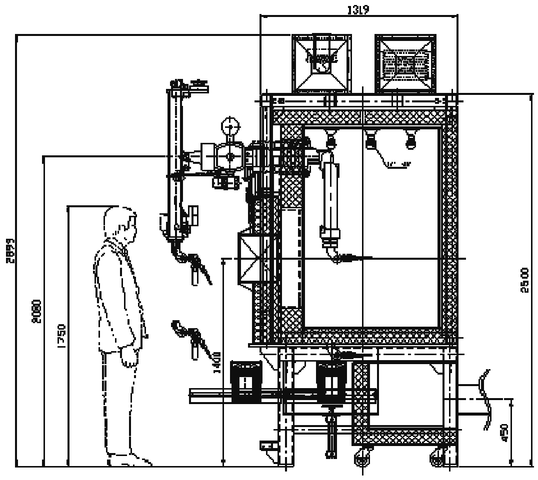

Fig. 2. Drawing of the Hot Cell for TR23 and TR103.

2.4 Sample Transport System

For the radiation safety of the operators and user, the activated samples will be stay at the target room till the gamma dose rate decreased to the value less than 12.5 μSv/hr. Many samples will have to be transported by remote sample transport system. The conceptual design of the target transport system is described in the Fig. 3. As shown in the Fig. 3, the sample will be transport to the hot cell via penetration between two rooms. The samples can be post-treated in the hot cell without excessive radiation exposure of the operators. To monitor the radiation during and after proton beam irradiation, radiation monitoring system will be installed at the surface of the hot-cell and nearby penetration.

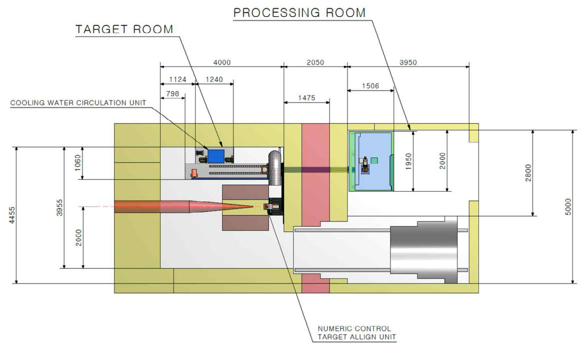

Fig. 3. Conceptual Design of the Sample Transport System for TR103.

The sample penetration will be plugged by iron block during proton beam irradiation to protect the radiation caused by secondary fast neutrons and prompt gammas.

3. Conclusions

For the high-current proton irradiation experiments at the TR103 and TR23, remote handling facility of radio-activated samples was designed. The system was consisted of hot-cell and sample transport system. The facility will be installed at the beam utilization building of the PEFP in this year. It will be very useful for the beam service which will be started from 2013.

ACKNOWLEDGEMENT

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