

Verification of the Thermal Neutron Shielding Effect of the Shielding Door of the LHD Experimental Hall

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Evaluating the performance of the shielding walls and shielding doors at radiation facilities is important to ensure proper radiation safety management. In the first period of the deuterium experiment, the neutron-shielding ability of the shielding door of the experimental hall containing the large helical device (LHD) was evaluated using the gold-foil activation method. The gold foil was inserted into a small gap between the shielding door and the shielding wall. Meanwhile, the shielding effect of the wall against the neutrons and gamma rays was verified using the badge-type dosimeters that were placed both inside and outside the experimental hall near the wall. The radiation derived from Au-198, which was visualized using by imaging plate, reached approximately 35 cm inside the shielding door. The results provided visual evidence that the shielding door safely excluded the thermal neutrons that were generated in an LHD. Furthermore, the measurement results of the badge-type dosimeters confirmed that the neutrons and gamma rays were completely trapped by the concrete wall of the experimental hall.

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The deuterium experiment project on the Large Helical Device (LHD) [1] started at March 2017. In radiation regulation in Japan, LHD is defined as a plasma generating device among the categories of radiation generating devices. In a radiation facility equipped with a radiation generating device, it is important that the radiation generated when the device will be operated is appropriately shielded by the shielding walls and the shielding doors. The LHD experimental hall is shielded by a 2-meter thick wall of normal concrete. And the walk-in entrance of the LHD experimental hall is equipped with a step-back type shielding door (2.58-meters wide, 3.28-meters high, and 2.0-meters thick, and weighs 40 tons).

The purpose of this study is to clarify the thermal neutron distribution from the inside to the outside of the shielding door and shielding wall at the first period (March 6th to March 17th, 2017) of deuterium experiment by using a gold foil activation method and badge type dosimeters for safety confirmation of radiation management.

Figure 1 schematically represents the LHD experimental hall. Figure 2 shows the Step step-back type shielding door of the walk-in entrance and the placements of the gold foils.

A gold foil (thickness 0.05 mm, 2 mm wide, 99.95% pure, Nilaco Corporation, Japan) was placed on the side of the shielding door for 12 days. Within this period, the first

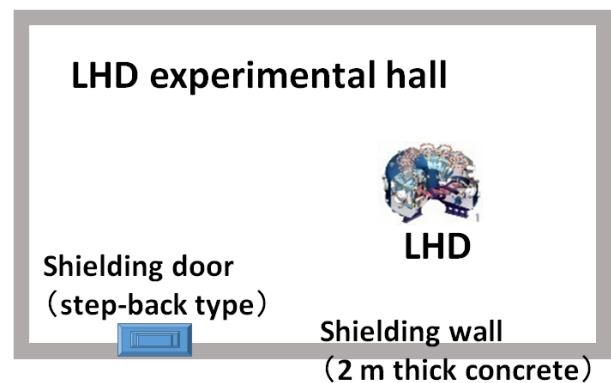


Fig. 1 Schematic of an LHD experimental hall.

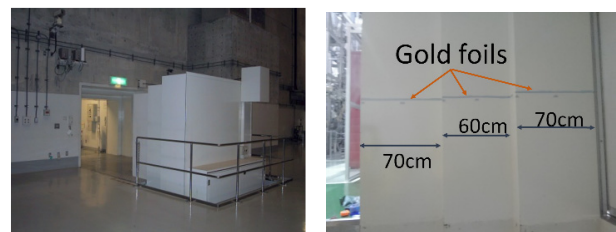


Fig. 2 Step-back type shielding door (left) and the placement of the gold foils (right).

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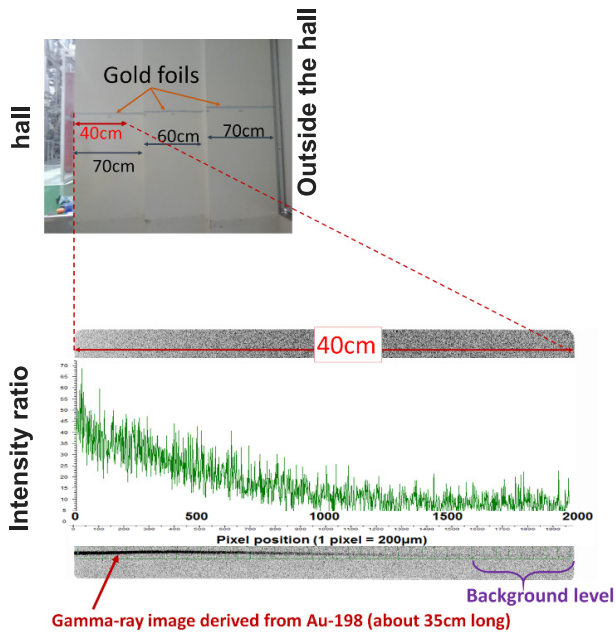


Fig. 3 Gamma ray image of gold foil imaged by IP and its intensity information.

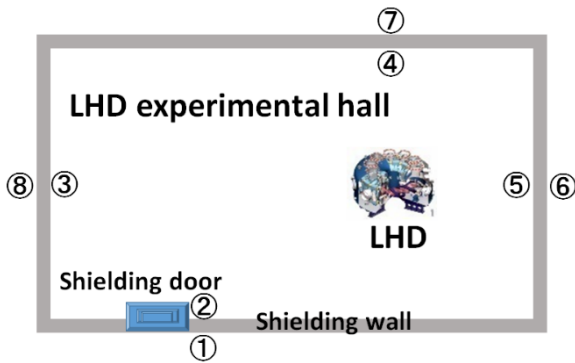


Fig. 4 Arrangement of the badge type dosimeters. Measurement points are labeled as ① to ⑧. All the dosimeters belonged to the Quixel badge N-type (Nagase Landauer, Ltd).

deuterium experiment was conducted over 8 days, generating 8.5×10^{16} neutrons.

The radiation from the activated gold foil was collected and measured on an imaging plate (IP) [1–3]. The IP was irradiated with activated gold foil for 40 hours under dark conditions. Figure 3 depicts the gamma-ray intensity image of the gold foil on the IP. The radiation derived from Au-198 [4, 5] was visualized up to approximately 35 cm inside the shielding door. The e-folding depth (approximately 12 cm) is observed to be reasonable by considering the transmittance of neutrons in concrete [6].

Figure 4 depicts the arrangement of the badge-type

Table 1 Dose results of the badge type dosimeters.

Place No.	Gamma-ray (mSv)	Neutron (mSv)	Total (mSv)
1(out)	0.00	0.0	0.00
2 (in)	0.81	4.9	5.71
3 (in)	0.62	6.0	6.62
4 (in)	1.05	4.8	5.8
5 (in)	1.68	10.6	12.28
6(out)	0.00	0.0	0.00
7(out)	0.00	0.0	0.00
8(out)	0.00	0.0	0.00

dosimeters placed inside and outside the LHD experimental hall during the first period of the deuterium experiment. Dosimeters 1, 6, 7, and 8 were placed outside the shielding wall, whereas dosimeters 2, 3, 4, and 5 were placed inside the hall. Table 1 presents the measurement results of the badge-type dosimeters. No doses were detected outside the shielding wall.

It is desirable to use a combination of Au foil and Cd coated Au foil to determine the ratio of thermal neutrons and epithermal neutrons. However we measured only the Au foil and obtained the thermal neutron intensity distribution because the gap between the shielding door and the shielding wall was as small as 1 mm or less. From the viewpoint of radiation management, thermal neutrons are easy to induce radiation activation, so it is meaningful to clarify the intensity distribution of thermal neutrons. Although the badge type dosimeter placed inside and outside the shielding wall was not able to know the distribution of the shielding ability, it is possible to evaluate the effectiveness of the shielding easily and inexpensively.

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