# §7. Separation Method for Measurement of Radiation Dose from Tritium in High Gamma-ray Radiation Fields by Using an Imaging Plate

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Tritium measurement is important from both viewpoint of tritium accountancy of fusion reactors and studies on tritium behavior in plasma facing materials. In particular tritium retention in plasma facing materials is one of the most important safety issues in fusion reactors. In the fuel- processing systems of deuterium-tritium (DT)-fusion facilities, gamma radiation deriving from components activated by neutron seriously affects tritium measurement. Separation measurement method of radiation dose from tritium and those from other nuclides is required. The main nuclides produced by neutron activation from Mo, Ni, Fe, and Cu contained in vacuum vessel (SS316) and superconducting magnet are $^{99}$Mo, $^{58}$Co, $^{57}$Co, $^{54}$Mn, and $^{60}$Co in Large Helical Device facility.[1] It was assumed that the same nuclides are produced by neutron activation in fusion reactors as well. Because of its long half-life (5.27 y) and high gamma emission energy (1.173 and 1.333 MeV), $^{60}$Co would be a main issue for tritium measurement.

In the present study, an imaging plate (IP) was applied to measure tritium detecting bremsstrahlung X-rays generated by the interaction between the beta particles from tritium and matter. Recently, the tritium IP technique has been successfully applied to determine the surface tritium distribution on plasma facing tiles.[2] The IP made of europium-doped BaFBr(I), a photostimulated luminescence (PSL) material, is a two-dimensional radiation sensor. This IP has many excellent properties for this purpose, including a high sensitivity, a wide dynamic range over five orders of magnitude, and a high degree of spatial resolution.[3] The PSL response of the IP has a peak at 20-50 keV and steeply decreases towards higher energy, falling by one hundredth at around 1 MeV, because the photostimulable phosphor is composed of elements with relatively high atomic numbers. Utilizing this strong dependence of the PSL sensitivities on energy, tritium/ $^{60}$Co separation measurement of radiation dose was attempted by using the IP.

Measurements were conducted by using four small borosilicate glass tubes, filled with pure tritium gas of 12.5, 25, 50, and 100 MBq, respectively as the tritium sources that generate bremsstrahlung X-rays. A $^{60}$Co point source was used as a gamma-ray source. A BAS-MS type-IP, manufactured by FUJIFILM Co., Ltd., was used to detect bremsstrahlung X-rays from tritium. The IP was irradiated for 1 h with the tritium sources and the $^{60}$Co source at dose rate in the range 0.0013 to 9.22 μGy/m, simultaneously. An ionization chamber, the EXRADIN model A-6 of 800 ml effective volume was used to monitor dose rate during irradiation with the $^{60}$Co source. Dose rate attributed to natural radiation was estimated to be 0.0013 μGy/m. The IP was read out by using the BAS5000 fabricated by FUJIFILM Co., Ltd. The PSL values from tritium were obtained by subtracting those with the $^{60}$Co gamma ray from total PSL values.

Fig.1 shows a relationship between PSL values from the tritium source and dose rate of irradiation with the $^{60}$Co source (μGy/m). It was found that the effect of irradiation with the $^{60}$Co gamma rays to the PSL values, obtained by irradiated with tritium of 12.5 MBq, was negligible up to dose rate of 4.380 μGy/m (3,370 times as high as natural radiation level). There was only 7.0% difference of the PSL values, obtained by irradiated with the 100 MBq tritium source, between dose rate of 0.0013 and 9.22 μGy/m. We can obtain separate PSL values for tritium and $^{60}$Co by attenuating bremsstrahlung X-rays induced by the tritium beta-rays using a thin filter such as aluminum or nickel foil. The IP tritium measurement method can be a promising candidate to measure tritium in high gamma-ray radiation fields.

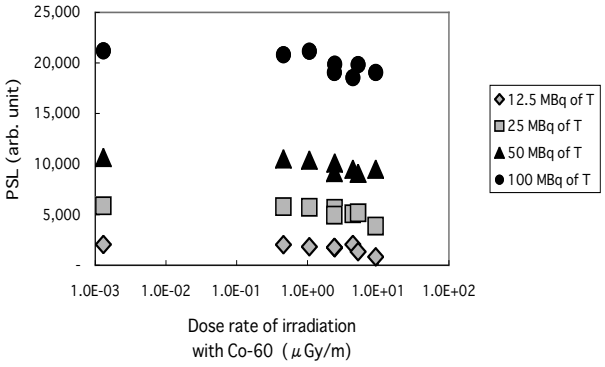


Fig. 1. Relationship between PSL values from the tritium source and dose rate of irradiation with the $^{60}$Co source (μGy/m).

1) Handa, H. et al.: Fusion Eng. Des. **17** (1991) 335
2) Tanabe, T. et al.: J.Nucl. Mater. **478** (2003) 313
3) Miyahara, J. et al.: Nucl. Instr. and Meth. **A 246** (1986) 572