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Shielding and Microdosimetric Measurement of High Energy Neutrons and LET-dependence of TLD

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INTRODUCTION

Firstly, the high energy neutron shielding measurements were carried out by using the Birratari-type rem-counter to obtain the attenuation coefficients of concrete, iron and polyethylene with and without boron, the angular distribution of dose equivalents. Secondly, the y-distributions were measured with Rossi-type tissue-equivalent proportional counters for the dose-equivalent estimations for workers around the facility. Thirdly, the LET-dependence of three-types of thermoluminescent dosimeters to the heavy ions. This experiment was planned to assess the LET in the body irradiated for the radiation therapy.

METHOD

1. Shielding measurements

The Birattari-type rem-counter shows a good dose equivalent dependence near to the 1000 MeV, in which a lead cylinder layer was put around the thermal neutron detector, BF3 counter or Helium-3 counter. The neutrons were produced by bombarding the carbon, copper and lead which have/u an enough thickness to stop the heavy ions of 400 MeV/u carbon, 600 MeV/u Neon and 800 MeV/u Silicon. Because of the larger thickness of the shielding materials, we used the wall of the experimental room and the concrete block used as the additional shielding. By applying the inverse square law and the exponential attenuation of neutrons in the materials, the attenuation coefficients and dose equivalents were calculated and are shown in Fig.1. As for the dose equivalent, some corrections seems necessary because of the distance between the target and the materials. The attenuation coefficients of iron were measured by comparing the attenuation by three pieces of 0.5m concrete and 1.0m concrete + 0 to 30cm iron. The center concrete was replaced by iron blocks with varying thicknesses. The 50cm concrete and 20 cm iron showed almost the same attenuations for all beams used. Angular distributions showed a sharp forward peak. The rem-counter reading in the corridor were 85% and 83% when the detector was surrounded with polyethylene blocks of 5cm thick with and without boron(10% content).

2. y-distribution measurement

The Rossi-type proportional counter(LET-1/2-SW) was used to measure the y-distribution in the mixed field of gamma-rays and neutrons around the target and to calculate the radiation quality. The counter was filled to 9.03 kPa with the tissue equivalent gas the base of which was propane. The equivalent diameter was 2μm. The pulse heights were converted with the logarithmic-amplifier developed by us. The x-axis was chosen as log(y) and y-axis was $n(y)=f(y_i)*\Delta(y_i)$. The lineal energy was obtained by dividing the energy imparted to a microsphere by an averaged diameter of the sphere 1(μm). The angular distributions of the lineal energy are shown in Fig.2.

3. LET dependence of TLD

Three types of thermoluminescent dosimeters, $CaSO_4$:Tb, Mg_2SiO_4:Tb and MgB_4O_7:Tb were used, the powder of which were encapsuled in a thin glass tube. The different LETs were obtained by varying the thicknesses of the energy absorber (Lucite). The responses of all dosimeters were linear in the low dose range, showing a supralinearity above several mGy and a saturation around 10Gy. The responses of three-type TLDs decreased with an increase of LETs of charged particles. Fig.3 shows the response for all three types of TLDs as ratios to the response to the Co-60 gamma rays.

DISCUSSION

1. Shielding measurements

Although an idealistic experimental configuration, such as varying shielding materials, was not realized, our data will provide basis for the estimation of radiation doses around the accelerator facility. Because of a forward peak characteristics, it is important to provide a thick wall in the zero degree direction.

2. y-distribution measurement

The charged particles from the copper target may contribute to a large frequency of high y values. We are going to measure the measurement behind the shielding materials with a 2 inch diameter counter.

3. LET dependence of TLD

We intend to find TLD materials which show a larger LET-dependence. A larger dependence of MgB_4O_7:Tb than other two materials on LET could be used to estimate the LET of the particles.

CONCLUSION

The present work will provide useful data in the design of the heavy charged particle medical facility. We will continue the radiation protection experiment in the facility.

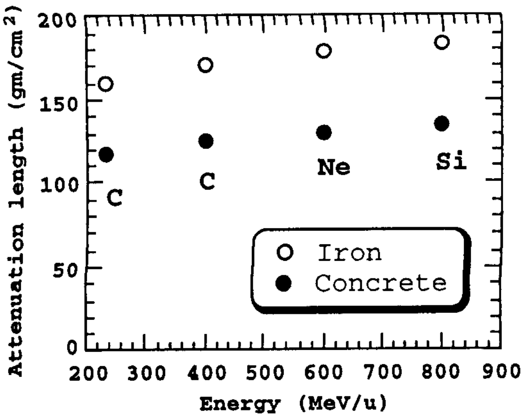

Fig. 1. The attenuation length.

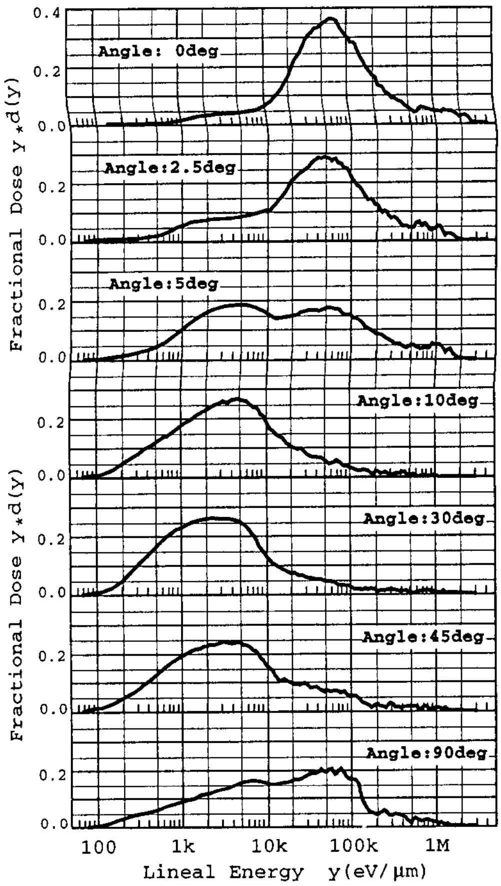

Fig.2. The lineal energy distributions around
a Cu target bombarded by 600MeV/u Ne ions.

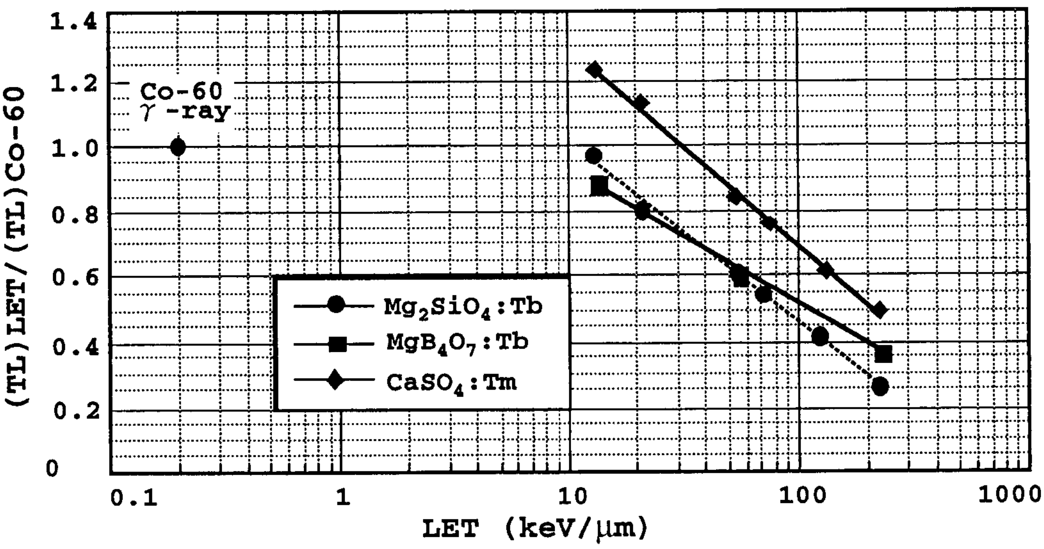

Fig.3. The characteristics of thermoluminescent dosimeters for heavy ions
in the range of low dose rates.