INTERCOMPARISON OF PROTON DOSE WITH TLD

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This work has been done as one of the US-Japan co-operative cancer research program. Four types of tissue equivalent thermoluminescent dosimeters of BeO, ^{6}LiF, ^{7}LiF and $Li_2B_4O_7$:Mn were used to get the spatial absorbed dose distribution in phantom irradiated by 52-MeV proton beam of FM cyclotron at Institute for Nuclear Study, University of Tokyo. The sizes of TLDs were powders encapsuled in a 1.2-mm-diam. by 8-mm glass tube for BeO, 1 x 1 x 6 mm^3 rods for ^{6}LiF and ^{7}LiF and 3.2 x 3.2 x 0.9 mm^3 ribbon for $Li_2B_4O_7$:Mn.

These TLDs were at first calibrated under the reference field of ^{60}Co gamma source at Institute for Medical Science, University of Tokyo. The exposure dose was 87.60 R/min and the absorbed dose was 84.84 tissue rad/min at 0.5cm depth in phantom. The average values of responses per tissue dose for ^{60}Co gamma rays were obtained as follows;

BeO	2.566 ± 0.113	tissue rad/rad in TLD reader
^{6}LiF	1.016 ± 0.026	"
^{7}LiF	1.144 ± 0.061	"
$Li_2B_4O_7$:Mn	91.78 ± 4.62	"

These dosimeters were arranged at 6.35 mm depth in acrylic plastics of density 1.19 placed perpendicularly to the proton beam. The proton beam was monitored by a Faraday cup connected to the current integrator. The proton beam was formed to have as a flatter top as possible by observing the beam profile with the multi-wire proportional counter, and at the same time more precise structure of beam profile was measured horizontally and vertically by scanning silicon dosimeters of 1.4-mm-diam. by 0.22-mm-thick disk.

The measured tissue absorbed dose per beam monitor counts are tabulated in Table 1 for four TLDs. Their values show good agreement each other with some distortions. The proton tissue dose clearly decreases with increasing the horizontal deviation of the TLD position from the beam center all for four TLDs, excluding several values. This entrance dose distribution well corresponds to the horizontal proton beam profile measured with silicon dosimeter which is shown in Fig. 1, such as 70 - 80 % at 1 cm and 85 - 95 % at 0.75 cm of the dose at the central position of the beam.

The measured results are compared with those by tissue equivalent ionization chamber of 1.3 cm diam. (IC). The TLD results show fairly good agreement with the IC results, but in general, the former gives higher dose values than the latter. This discrepancy can be explained from the following two facts:

1) TLDs were all placed behind 6.35 mm acrylic plastics and IC was behind 3 mm PPTEP window.
2) The IC size is about 10 times larger than the TLD sizes, so the absorbed dose averaged in IC becomes less than that in TLD, since the beam profile has not a flat top as seen in Fig. 1.

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Table I Entrance Dose[1] of the 52 MeV Proton Beam

Dosimeter	Position Horiz.	Position Vert.	Proton Tissue Dose (rad)		
Ionization Chamber	1.3 cm$^{\phi}$		89.03	176.6	
BeO	-0.75 cm	±0.4 cm	106.3	238.6	
	-0.35	"	115.2	266.5	
	0.0	"	114.2	211.4	
	0.35	"	——	210.7	
	0.75	"	——	196.3	
Ionization Chamber	1.3 cm$^{\phi}$		88.41	176.1	
^{6}LiF	-1.0 cm	±0.3 cm	96.68	175.6	
	-0.5	"	106.8	187.9	
	0.0	"	113.2	198.7	
	0.5	"	98.90	197.3	
	1.0	"	60.80	139.9	
Ionization Chamber	1.3 cm$^{\phi}$		88.53	175.9	
^{7}LiF	-1.0 cm	±0.3 cm	92.98	177.9	
	-0.5	"	105.1	187.9	
	0.0	"	119.2	224.3	
	0.5	"	——	242.4	
	1.0	"	——	195.4	
Ionization Chamber	1.3 cm$^{\phi}$			177.1	1755.6
$Li_2B_4O_7$:Mn	-0.75 cm	±0.4 cm		194.7	2116.4
	0.0	"		204.3	2492.4
	0.75	"		185.2	2644.7
	-0.35	-0.4		204.4	
	0.35	"		228.9	
	-0.75	"			2111.9
	0.0	"			2182.6
	0.75	"			2192.4

1) TLD were all placed benind 6.35 mm acrylic plastics and the ionization chamber was benind 3 mm PPTEP window.
2) The position of TLD indicates the horizontal and vertical deviations from the beam center.

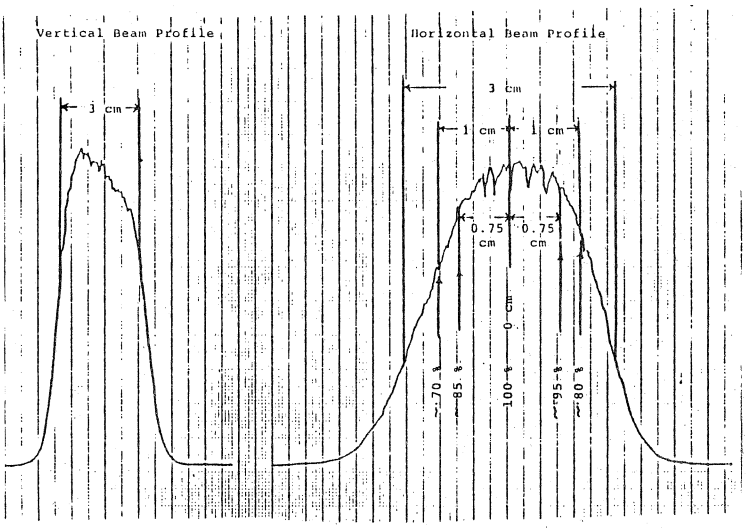

Fig. 1 Proton beam profile measured with silicon dosimeter