SELF RADIATION SHIELDING ON THE BABY CYCLOTRON

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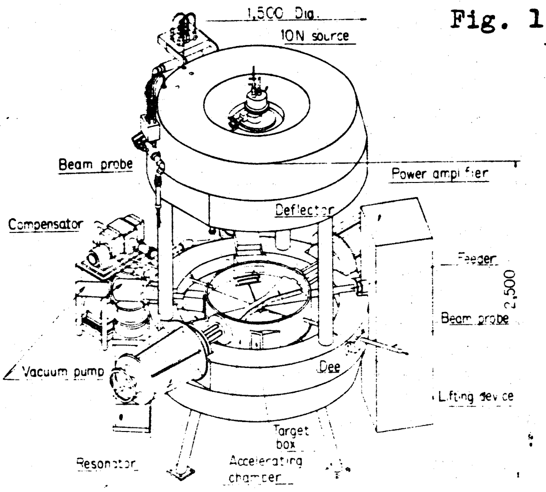
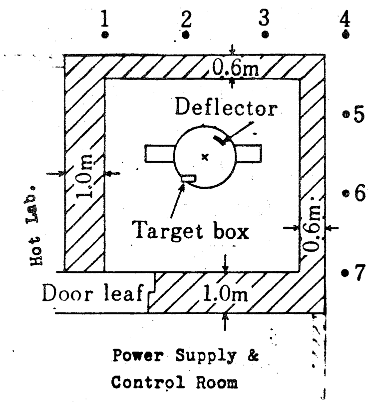
The baby cyclotron aimes particularly at radioisotope production of ^{11}C, ^{13}N, ^{15}O and ^{18}F in a hospital. One of features of the cyclotron is self radiation shielding[1]. The cirular magnet yoke surrounding the cyclotron absorbs radiation coming from inside the cyclotron including target box. A bird-eye view of the cyclotron is shown in Fig. 1.

Fig. 1



A prototype of the cyclotron has been installed at the National Nakano Chest Hospital in Tokyo at spring of 1979 and radiation levels around the facility have been surveyed. The results of the measurements and preliminary discussion about self radiation shielding is reported here.

Fig. 2



The layout of the facility is shown in Fig. 2 and measuring points of dose rate are also shown by indexes. Neutron radiation levels are measured by the neutron dose rate meter 2202D made by Studsvik (Sweden). This instrument measures the neutron dose rate in the unit of mrem/h with approximately correct rem dose response in the energy range from thermal to 17 MeV. The ratemeter range is logarithmic from 0.1 to 10,000 mrem/h and counts of pulse per unit time indicate dose rate below 0.1 mrem/h.

The results of the survey are shown in the "A" row of Table.

point		1	2	3	4	5	6	7	20	21	23	24
$\frac{\mu rem}{h}$	"A"	6	50	43	5	34	12	2	3	-	-	-
	"B"	140	350	49	12	38	41	31	167	9	43	30

Target Current; 6μA. Beam Extruction Efficiency; 30% E_p=9.4MeV. "A"; N_2gas.
"B"; C_u plate at outside of the yoke. Point 1-7; 0.5m distance from 0.6m thickness concrete wall, at intervals of 2m, 1.6m hight from ground. Point 20-24; on the loof, 20; center. Others; 2m from center on the diagonal.

Radiation levels arising from γ-rays are of course negligible and nearly natural background at these points. In operation of the cyclotron, neutron may be produced at three portions, where internal beam strikes dee or dummy-dee, the greater part of non-extracted beam strikes the septum at entrance of the deflector and extracted beam bombards target material. In our case, nuclear reaction for radioisotope production is $^{14}N(p,\alpha)^{11}C$ and accompanied $^{14}N(p,n)^{14}O$ reaction generats a little neutron owing to small cross section at the target box. The septum of the deflector is made from tantalum or wolfram and then the cross sections of (p,n) reaction are small at the proton energy of 9.4 MeV. A little spill beam strikes the deflector electrode made from copper. Then main neutron that must be shielded may generate about maximum radius by the internal beam striking the dee or dummy-dee. When the internal beam is stopped by the beam probe made from copper, the radiation levels are same as the case of radioisotope production. When copper is changed by tantalum at the top of the beam probe, the radiation levels decrease from one third to one tenth.

For validity of self radiation shielding, an experiment has been done as follows. We installed the target box outside of the magnet yoke and thick copper target was irradiated by the same operation condition of the cyclotron. Measured radiation levels are shown in the "B" row of the Table.

Reference

1) T. Karasawa; Japanese patent 818015, U.S.A. Patent 3921019
French Patent 2209272