Leakage Radiation and Residual Activities in the Ring Cyclotron Facility

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Abstract

In December 1986 the first beam was successfully extracted from the Riken Ring Cyclotron (RRC). Subsequently many instruments have been installed to do experiments. The energy of beams has been raised since 1989. In this report leakage radiation and residual radioactivities in this period are described.

Introduction

A short history of the RRC is as follows:

In December 1986 the RRC came into operation and a beam line became available for experiments in the experimental vault E1.

In 1988 beam lines became available for experiments in the experimental vaults D, E2, E3, and E7.

In 1989 the injector AVF cyclotron came into operation and the maximum beam energy of the RRC became from 75 MeV/u to 135 MeV/u. More beam lines became available for experiments in the experimental vaults E4, E5, and E6.

In 1990 a new beam line became available in a newly extended experimental vault E5.

For leakage radiation, the radiation safety control system has worked steadily since 1986, performing radiation monitoring continuously and automatically with fixed neutron and γ-ray counters. In addition spot monitoring has been performed with neutron dose rate meters.

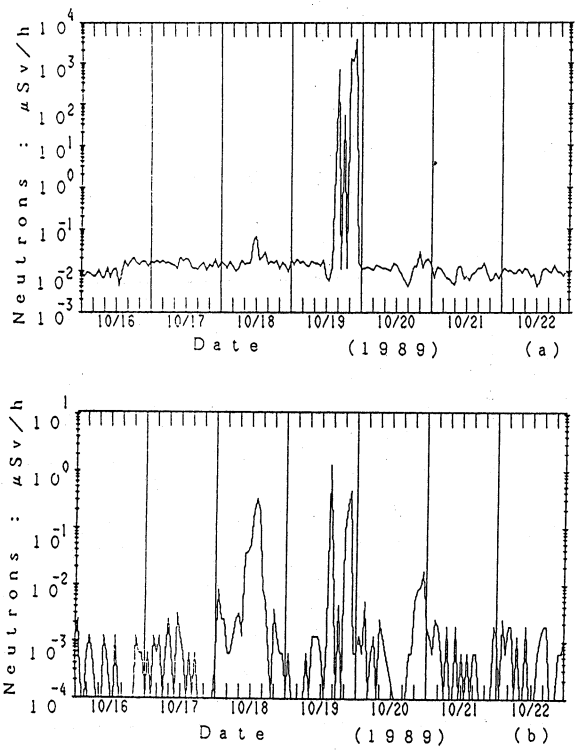

Fig. 1. Daily variation in the radiation level measured in the Ring Cyclotron facility.
Measurement was done using a BF_3 counter (a) in the experimental vault E3, and (b) in the experimental vault E4. The beam current corresponding to the highest dose rate was about 30 nA. (Ref. 3 .)

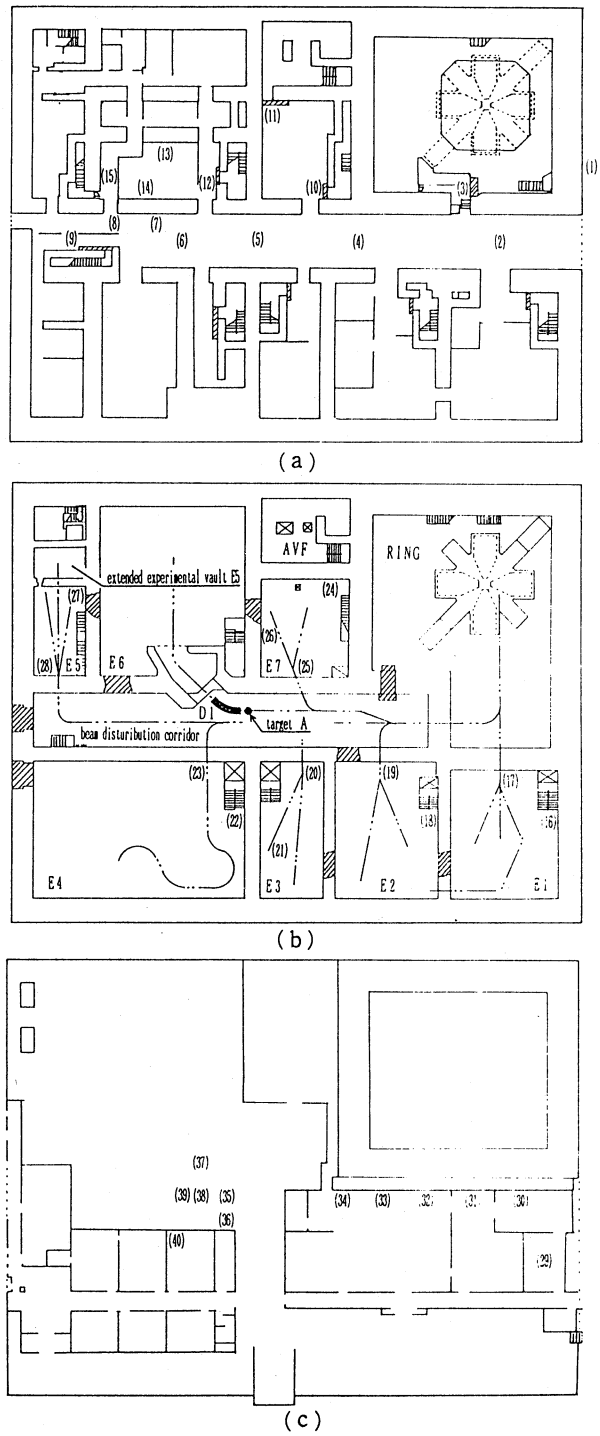

Fig. 2. Layout of the RIKEN Ring Cyclotron facility.
a : Plan view of 2nd basement;
b : Plan view of 1st basement;
c : Plan view of the first floor.
Points where dose of leakage radiation was measured are denoted by the number in parentheses.

We also measure residual activities of the Ring and AVF cyclotron every summer and those along the beam lines after every experiment. The results of measurement have been reported in annual reports[1,2,3,4] since 1986. Here we summarize these measurements.

Leakage radiation

Leakage radiation between 1986 to 1988 was very little because the maximum beam energy of the RRC was 75 MeV/u. However, since the AVF cyclotron completed in 1989 and then the maximum beam energy of the RRC became 135 MeV/u, leakage radiation began to be detected at many places in the facility as shown in fig.1, for example.

On October 19 an experiment was carried out using a ^{14}N beam of 135 MeV/u, which was the highest energy in that year, in the experimental vault E3. Figures 1 shows the daily variation of dose rates recorded in the neighboring vault E4 as well as E3: (a) neutrons were measured with a BF_3 counter in the experimental vault E3; (b) leakage neutrons were recorded with the same-type counter in the expremental vault E4. Leakage neutrons during beam tuning in the beam distribution corridor D were also recorded on October 18 and at midnight October 20.

We show another data obtained with neutron dose rate meters in March 1990.[5] On March 22 an experiment was carried out with a 100 MeV/u $^{18}O^{8+}$ beam at a particle intensity of 44 pnA in the experimental vault E6. The primary beam was stopped at a target A located in front of a dipole magnet D1 in the beam distribution corridor. Leakage radiation of neutrons was measured with four neutron dose rate meters, three 2202D's of Studvik and an NSN1001 of Fuji electric. The 2202D's were used with pulse counters because of their low sensitivity to neutrons; NSN1001 was used alone because of its high sensitivity. Figures 2 a,b, and c show the target A and positions in which leakage radiation was measured. Results are summarized in Table 1. Now we are measuring neutron dose rate per unit current at various points in the facility.

Table 1
Neutron dose rates of leakage radiation from a target A in the beam distribution corridor. (See Figs.2 a,b,c.) A letter "A" stands for the neutron dose rate meter of 2202D Studsvik No.83064, "B" 2202D of Studsvik No.89006, "C" 2202D of Studsvik No.86032, and "D" NSN1001 of Fuji electric.

Measured point	Detector name	Count rates (C/3min)	Dose rates (μSv/h)
(1)	B	0	0
(2)	A	0	0
(3)	C	2	0.03
(4)	C	17	0.22
(5)	C	89	1.15
(6)	B	184	3.10
(7)	A	38	0.64
(8)	C	4	0.05
(9)	B	2	0.03
(10)	B	0	0
(11)	C	0	0
(12)	B	0	0
(13)	C	0	0
(14)	B	0	0
(15)	A	0	0
(16)	C	3	0.04
(17)	C	42	0.54
(18)	C	6	0.08
(19)	C	34	0.44
(20)	B	9	0.15
(21)	B	5	0.08
(22)	B	22	0.37
(23)	B	110	1.85
(24)	B	6	0.10
(25)	B	82	1.38
(26)	C	15	0.19
(27)	B	0	0
(28)	B	0	0
(29)	D	-	0.002
(30)	D	-	0.002
(31)	D	-	0.020
(32)	D	-	0.018
(33)	D	-	0.029
(34)	D	-	0.006
(35)	D	-	0.055
(36)	D	-	0.040
(37)	D	-	0.029
(38)	D	-	0.059
(39)	D	-	0.030
(40)	D	-	0.006

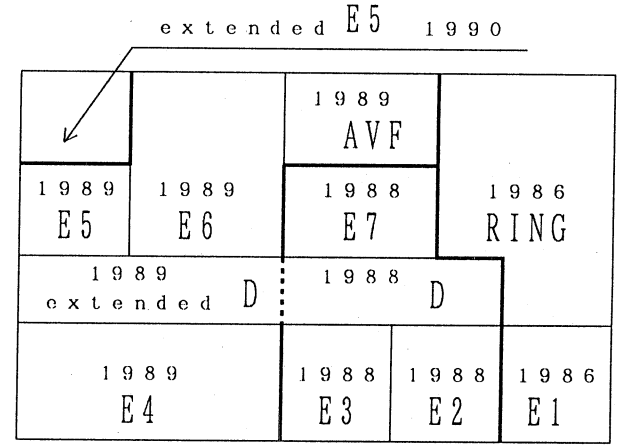

Fig.3. Schematic layout of the RRC facility. Digits indicate when the room was completed.

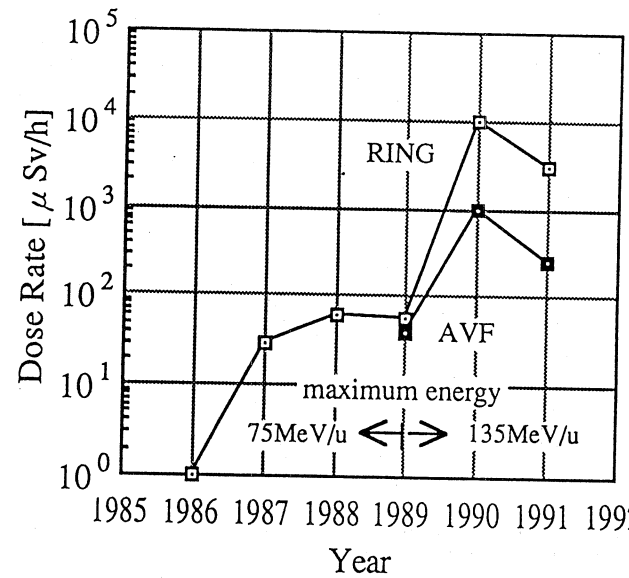

Fig.4. Variation of residual activity of deflectors of the RRC and the injector AVF cyclotron.

Residual Activities

Monitoring areas have been extended with expansion of accelerators and experimental vaults since 1986. (See Fig. 3 .)

The result of measured residual activities in accelerators and beam lines has been reported annually. Figure 4 shows variation of residual activities of deflectors of the RRC and the injector AVF cyclotron.

In Fig. 4 residual activity at deflectors from 1986 to 1988 was several 10 μSv/h, but it has become several 1000 μSv/h since 1990. It is considered that this is due to the increase in energy of beams from the RRC from 75 MeV/u to 135 MeV/u. The RRC will be operated at much higher beam intensity before long. Eventually the residual activities are expected to become higher.

References

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