Radiation Safety issues for the PF-AR in KEK

H. Nakamura, S. Ban, K. Iijima ,Y. Namito and K. Takahashi

High Energy Accelerator Research Organization(KEK), 1-1 Oho, Tsukuba-shi, Ibaraki-ken, 305-0801, Japan

Abstract

The ambient dose rates in the experimental halls of the Photon Factory Advanced Ring (PF-AR) are measured with the area monitors. The dose rates are usually background level. However, when the beam lifetime decreased suddenly, the dose rates increase. This phenomenon is considered bremsstrahlung due to dust trapping near the duct. We measured the dose rate during the phenomenon and made radiation protection.

1. Introduction

1.1. Present status of the electron accelerators in KEK

There are three electron rings, a positron ring and an electron-positron linac in High Energy Accelerator Research Organization (KEK). Figure 1 shows the location of these accelerators. Two of the electron rings are the Photon Factory (PF) and the Photon Factory advanced ring (PF-AR) used for synchrotron radiation experiments. One of the electron rings (HER) and the positron ring (LER) are used for electron-positron collision experiments (KEKB). The electron-positron linac injects four different beams into the four rings.
The recent improvement in KEK is a simultaneous Top-UP injection for the 3 rings (HER, LER, PF). The simultaneous injection has started since 24th April 2009. The linac provides simultaneously 8 GeV electrons to HER, 3.5 GeV positrons LER, and 2.5 GeV electrons to PF by using the pulse to pulse switching injection system [1]. Figure 2 shows the 3 rings keep the constant current except during PF-AR injection.

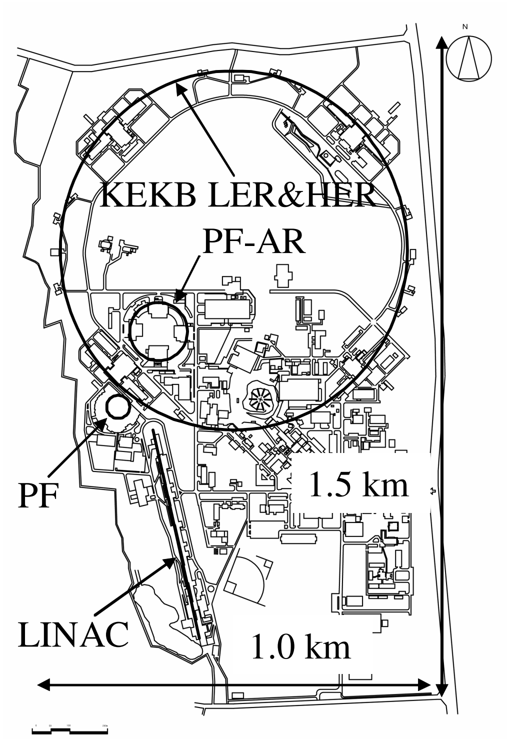

Fig.1 - Plan of electron accelerators in KEK. LINAC locates southwest part in KEK. PF ring locates west of LINAC end. PF-AR ring locates north of LINAC. KEKB 2 rings locate north part of KEK.

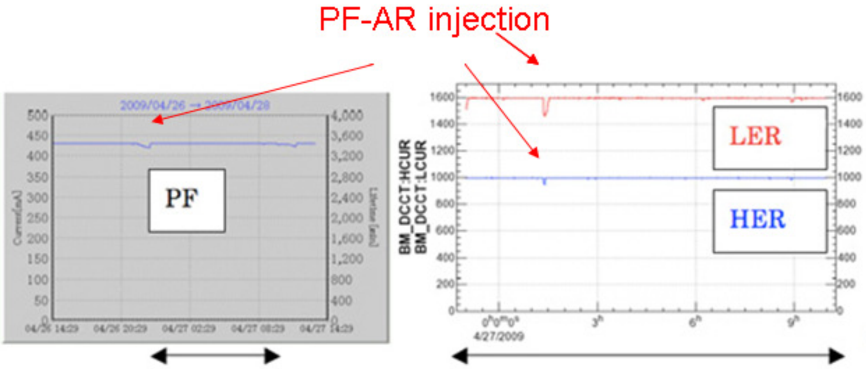

Fig.2 - PF, LER and HER keep each constant current except during PF-AR injection.

1.2. Outline of the PF-AR

The PF-AR is a 6.5 GeV synchrotron radiation source, which operated with single bunch for pulsed hard X-rays. The ring is injected at 3.0 GeV, after that the beam is accelerated to 6.5 GeV and stored initially at 60 mA. The ring has 8 beam lines and 6 insertion devices. Table 1 shows main parameters of the PF-AR[2].

Beam energy	6.5 GeV
Circumference	377 m
Injection energy	3.0 GeV
Typical num. of bunches	1
Initial stored current	60 mA
Beam lifetime (at init.cur.)	20 hours
Num. of insertion devices	6

Table 1 - Main parameters of the PF-AR.

2. Management of radiation safety in the PF-AR

The experimental halls of the PF-AR are radiation controlled areas. The ambient dose rate in the halls should be controlled less than 20 µSv/h. The dose rate is measured by the area monitors named ORG monitors. Figure 3 shows the appearance of an ORG monitor. The monitor consists of a 10-liter ionization chamber for gamma detection and a 1-inch BF3 proportional counter for neutron detection. The monitors give an alarm when the dose rate is over 20 µSv/h. Figure 4 shows the locations of the monitors in the experimental halls of the PF-AR.

The users of the PF-AR should be the radiation workers of KEK. The limit of annual personal effective dose is 20 mSv for the male radiation workers and 6 mSv for the female radiation workers. Target of the personal effective dose is less than 7 mSv for the male workers and less than 2 mSv for the female workers. In Fact, most of the workers are not exposed significantly.

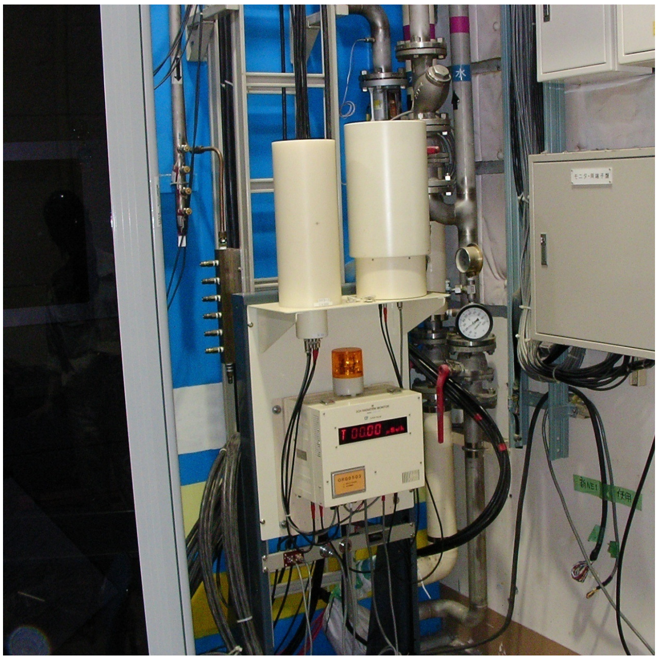

Fig.3 - An ORG monitor consists of a 10-liter ionization chamber for gamma detection and a 1-inch BF3 proportional counter for neutron detection.

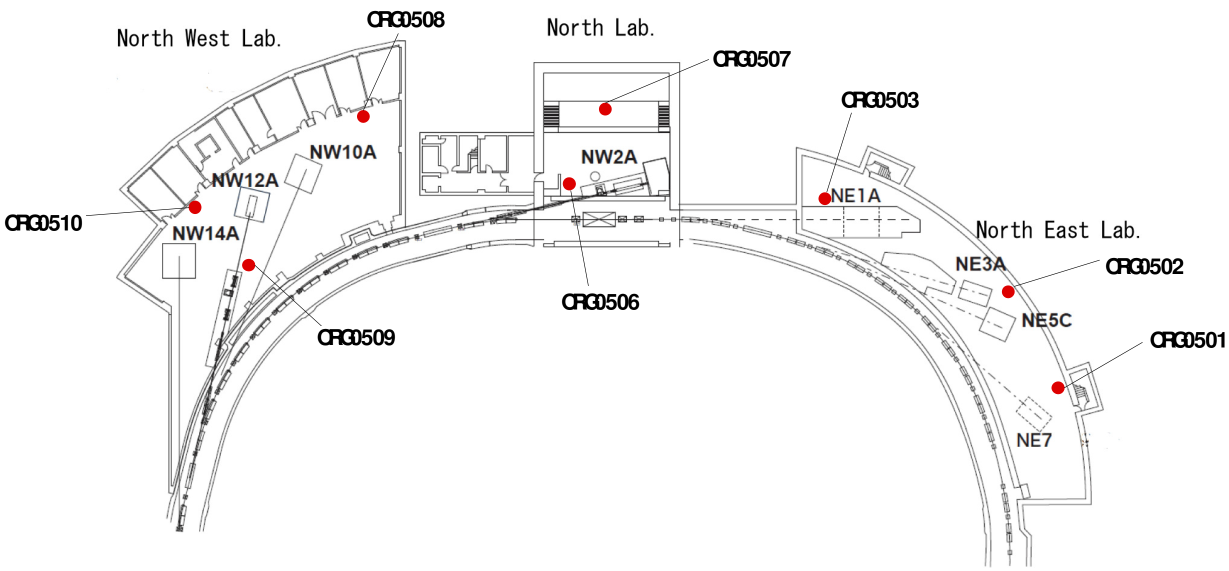

Fig.4 - The locations of the ORG monitors in the experimental halls of the PF-AR.

3. Measurements and studies

Usual ambient dose rate in the experimental halls is background level. However, the dose rate increases when the beam lifetime of the PF-AR decreases suddenly. Figure 5 shows a typical example of the incident occurred at the NW12 beam line in the North West experimental hall. When the beam lifetime decreased from 500 minutes to 100 minutes, the gamma dose rate at ORG0509 monitor increased from 0.1 μSv/h to 1.6 μSv/h and the neutron dose rate increased from 0 μSv/h to 0.2 μSv/h. At that time, ORG0509 monitor was located at the wall of the experimental hall, therefore, there was little information about the dose rate around the beam line.

When another similar incident happened, we measured the dose rate around the NW12 with survey meters. Figure 6 shows the dose rate around the NW12. The maximum dose rate at the surface of the NW12 hutch was 230 μSv/h.

The measurements showed the following conditions for the incident. Changing narrowly the gap of NW14 insertion device which located upper stream of NW12 often triggered the incident. The vacuum level was worse. The beam lifetime decreased. The dose rate around the NW12 increased, however not increased around other beam lines. The dose rate returned to background level when the main beam shutter (MBS) in the beam line was closed.
Since the beam orbit of the ring was newly arranged for installing new beam line NW14, it was suspected for the cause of the incidents. The operation with the old beam orbit was tested. However it did not change the situation.
Measurement of residual radiation from the beam duct of the ring showed the duct near the steering magnet of NW12 was activated. This phenomenon is considered bremsstrahlung due to dust trapping near the duct[3].
Checking the log of the monitors showed similar incidents were occurred before.

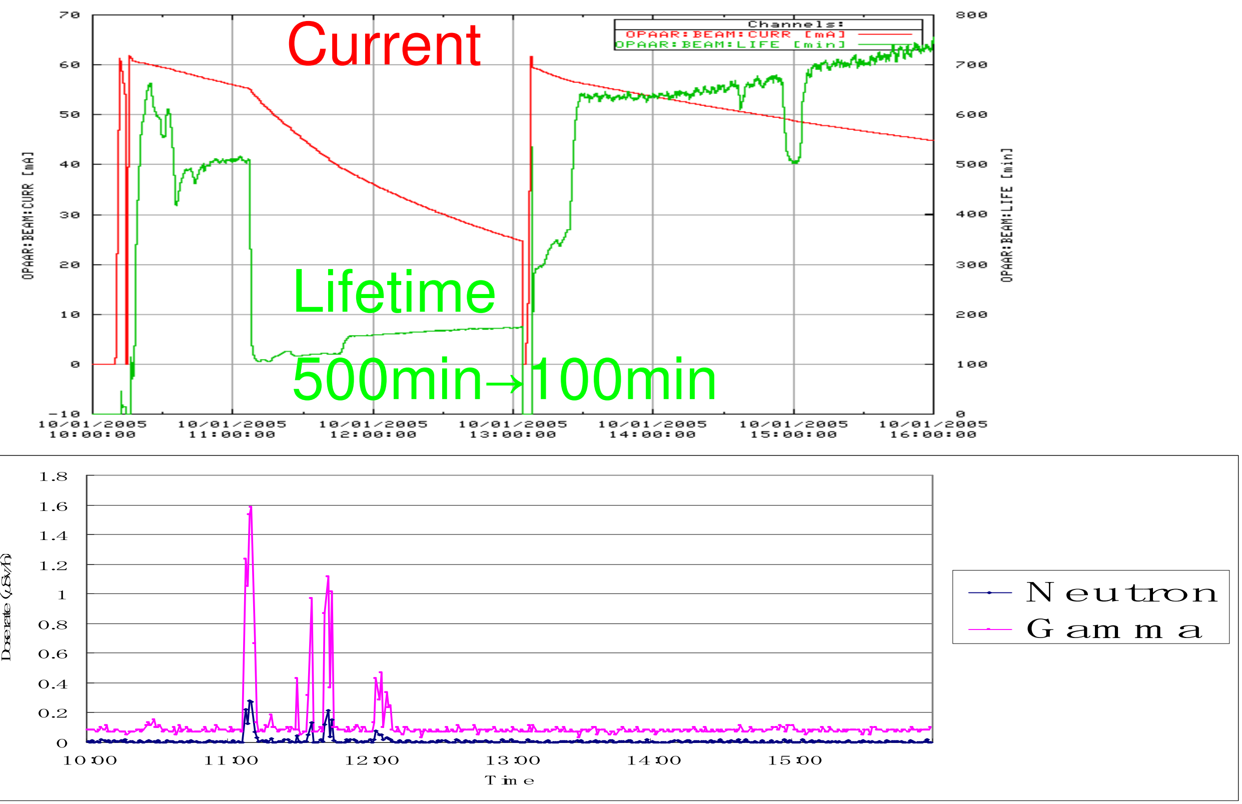

Fig.5 - An example of the sudden beam lifetime decreasing and increase of the dose rate at the ORG0509 monitor in the experimental hall.

4. Measures for safety

The followings were first things what we did for the safety in the experimental hall. We set up the area where people were not allowed to enter because of high dose rate. We changed temporarily the alarm level of the ORG monitors in the experimental halls from 20 μSv/h to 1 μSv/h for detecting the incidents occurred far from the monitors.
Next, lead blocks were installed in the optic hutch of the NW12.
An ionization chamber for interlock was installed out of the optic hutch. It closes the MBS when the dose rate exceeds 5μSv/h and continues for 3 minutes.
Finally, ORG0509 monitor was moved to near the optic hutch of the NW12 for detecting radiation effectively.

5. Results

Nobody in the PF-AR was exposed to significant radiation. The frequency of the incident around NW12 decreased. Other beam line (ex. NE3) also had the incident, but not so often. One of sources of the dust is considered distributed ion pump (DIP)[4].The frequency of the incident has decreased since DIP-OFF operation started.

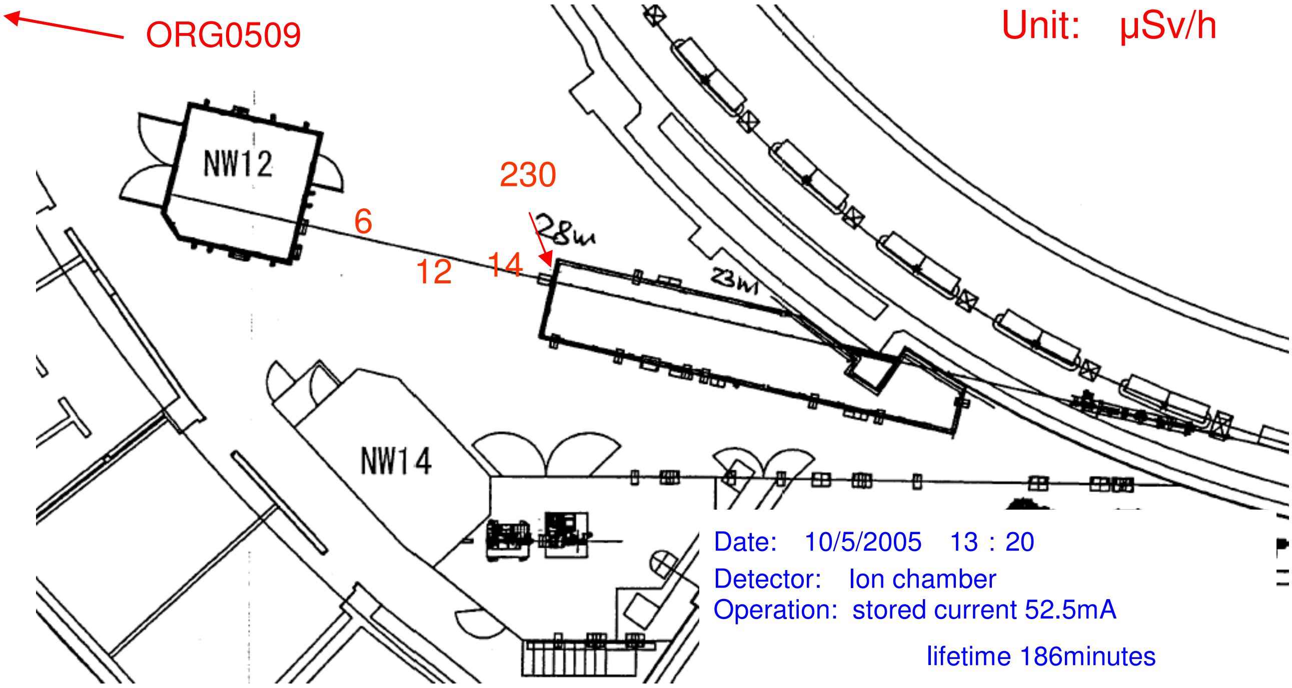

Fig.6 - The dose rate around the beam line NW12 during the beam lifetime decreasing.

References

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