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# Radiation Shield and Safety System for the JAERI FEL

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Abstract

Outline of the superconducting linac for the JAERI FEL facility, the radiation shielding and an interlock system are described briefly.

## 1.Introduction

Free electron laser(FEL) is an expected machine to produce powerful light of variable wave length, which is useful for the basic research and application.

In JAERI, Tokai, we are constructing a prototype FEL using a superconducting linac, aiming at long pulse lasing in the infra-red region. The FEL is composed of a electrom gun, sub-harmonic buncher, superconducting accelerators, beam transport magnet system, undulator, optical resonator, vacuum system, refrigerator system, control system, and radiation protection system. They are installed in a joint space of old and new buildings, of which floor level is 2.5m under the ground level. Cutaway view of the FEL facility is shown in Fig.1.

The injector is designed to produce electron beam of 250 kV maximum energy, with a complex pulse structures. The beam is bunched by a sub-harmanic buncher (83.3 MHz), and is accelerated by two superconducting pre-accelerators (499.8MHz) to an energy of ~2 MeV. Then it is accelerated to 10~17 MeV through the two superconducting main accelerators (499.8MHz). The beam is transported to the undulator and a beam dump. In the undulator, production of infrared light of 20 ~ 40 μm wave length is expected by the spontaneous emission and lasing. Because the maximum average beam current is designed to be 40 μA, and average beam power 0.8 kW, the radiation protection is a important problem.

The FEL was licensed as a radiation production facility in July 1993, by the Japanese govenment, the Science and Technology Agency. We are now continuing beam acceleration tests and adjustment of the components.

In this article, are described briefly the radiation shield of the accelerator room and an interlock system of the building.

## 2. Radiation Shield

During operation of the accelerator, strong gamma ray photons are produced along the beam duct and at the beam dump. To keep irradiation dose for operation staff below acceptable value of 50mSv/y, we have made (A) a shielding room for the accelerator, and (B) an interlock system to keep out person from dangerous region during operation.

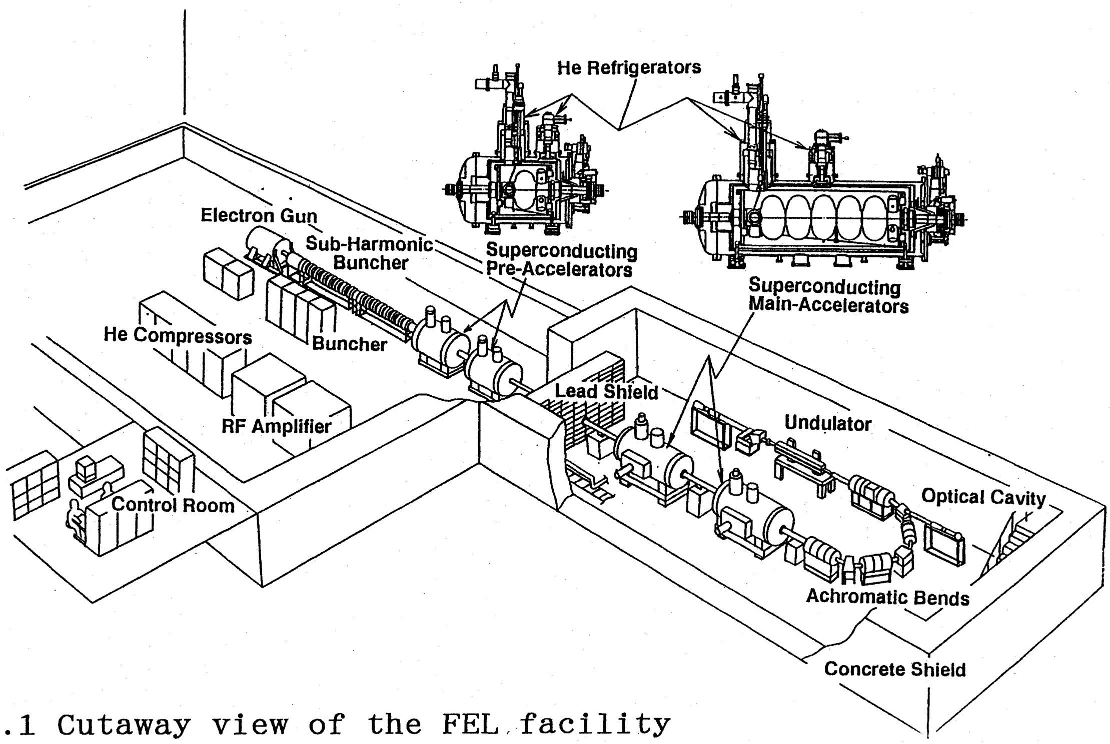


Fig.1 Cutaway view of the FEL facility

Radiation dose rate due to bremsstrahlung D(Sv/h) at L(m) from a source point were estimated for an electron beam of energy E(MeV), and beam power P(kW), assuming that the beam bombards thick target of high-Z materials.[1] Dose rate in forward direction is approximately,

$$D \sim 20 \times E^2 \times P \times L^{-2} \text{ (Sv/h)} \quad (E < 20 \text{ MeV})$$

and in side direction,

$$D \sim 50 \times P \times L^{-2} \text{ (Sv/h)}.$$

Following assumptions are made for the dose rate estimations.

(1) The maximum operation rate of accelerator is 20MeV, 40μA, and beam power 0.8 kW.

(2) Only side direction component contribute to the radiation field on the ground level, because the electron beam line situate in a horizontal plane 1.3 m under the ground level.

(3) $10^{-4}$ part of the main beam spills along the beam duct.

(4) At the beam dump, the electron beam is bent 60 deg. downword by a magnet, and side direction component is attenuated to $3\times10^{-5}$ by a lead shield surrounding the target.

(5) Sudden change of accelerator parameters cause the beam to strike the beam duct. When a radiation monitor detect anomalous radiation level, RF was stopped through the interlock system within a short time < 100 μs.

On the above assumptions, average radiation source strength at the center of accelerator room is estimated to be 20mSv/h at 1m.

To reduce dose rates below acceptable value in the non-regulated region, the thicknesses of concrete wall and ceiling of the accelerator room are designed to be 40 cm and 90 cm, respectively, considering operation schedule of the accelerator. Auxiliary soil shield was settled outside the wall of the accelerator room. Sections of the accelerator room are shown in Fig.2.

## 3. Interlock System

To inhibit deteriolation of the accelerator components by operation as well as to protect person from radiation hazard, an interlock system was constructed. As to the radiation protection, the system detects the status of the following three kinds of hard-wired switches, and displays on a panel by LED.

(1) door interlock

There are four routes between the safety region and the hazardous region. A door switch is set on the door of each route. If one of these door is open, the accelerator stops instantaneously, or unable to operate.

(2) personal key

When a persons goes in to the hazardous regin, he must pick off a personal key from a panel in the control room. Then, the accelerator stops, or unable to operate. When he comes back from the hazardous region, he must undo the personal key.

(3) stop key

Stop keys are placed at several points in the hazardous region. When a person works in the hazardous region, he must switch-off one of the stop key. Then the accelerator is unable to operate.

The radiation shield and the interlock system will assure reliable environment for staff if they use properly.

References.

[1] W.P.Swanson: Radiological Safety Aspects of the Operation of Linear Accel-erator,
IAEA Technical Report No.188(1977)

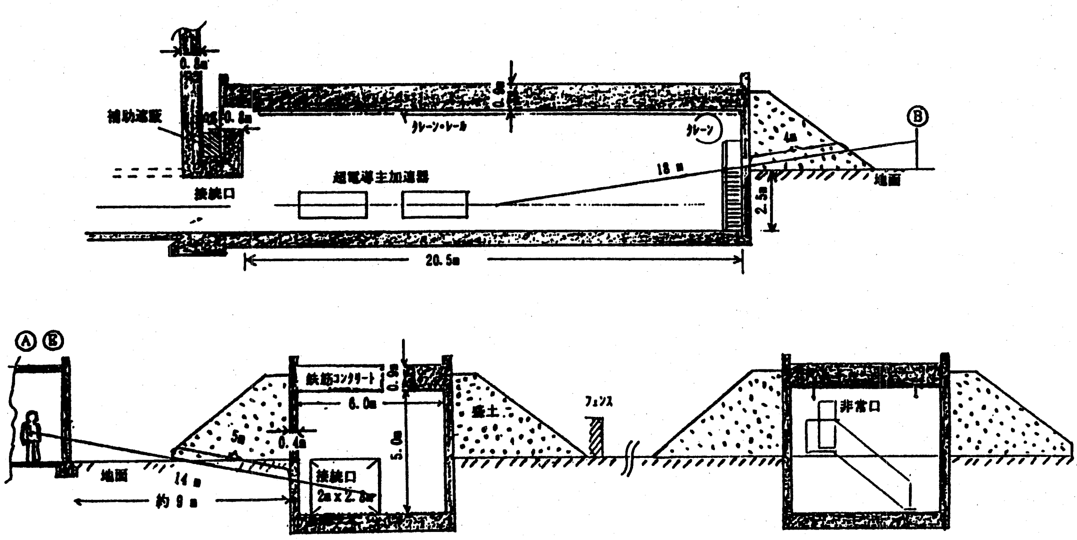


Fig.2 Sections of the accelerator room