Preliminary Radiological Considerations for X-ray Free Electron Laser Project at PAL

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1. Introduction

In last two decades, synchrotron facility has been proven very fruitful in new science and technology and many remarkable results have been produced using Pohang Light Source (PLS), the 3rd generation synchrotron facility. Recently more improved synchrotron radiation source, very short and very high intensive VUV or X-ray, have been required in those fields and the construction project of the 4th generation synchrotron facility, SASE (Self Amplified Spontaneous Emission)-FEL or ERL (Energy Recovery Linac), were launched into at USA, EU, and Japan [1,2,3,4]. PAL started to study for the X-ray Free Electron Laser (XFEL) project using its one long electron linac, which are unique advantage for this project. In this paper, the PAL XFEL Project is introduced and preliminary radiological considerations for radiation protection are presented.

2. PAL XFEL

The PAL XFEL will consist of electron linac of 3 GeV, short period in-vacuum undulator of 70 m long, and 200 m long X-ray beam line for 0.1 ~ 0.3 nm photons. At present the parameters of PAL injector linac of Pohang Light Source are 2.5 GeV electron, 1 nsec beam pulse width, and 10 Hz beam pulse repetition rate. The long electron linac is a basic start point to construct XFEL facility. This linac will be extended and modified to make better quality electron beam with energy of 3 GeV and a pulse length of subpicosecond, and a pulse repetition rate of 60 Hz. The beam charge is 1 nC/pulse. The three SASE-FELs will be constructed as shown in Figure 1. Main parameters of synchrotron radiations are designed as these: λ_x=10~50 nm (FEL1), λ_x=2~5 nm (FEL2), and λ_x=0.1~0.3 nm (FEL3), respectively.

3. Radiological Considerations

Many radiological problems are the same to those from present PAL injector linac because of the same-grade (similar electron energy and beam power) electron linac. Therefore the shielding structure equivalent to 3 m thick ordinary concrete will be required along whole acceleration tunnel and undulator tunnel. Because of low electron energy below 3 GeV, moun production is not considered, too. However the gas bremsstrahlung in the long undulator will be more serious in comparison with one of a storage ring of the 3rd generation synchrotron source and be able to make a serious problem at the front-end area of synchrotron radiation beam line. The mis-steering at a dumping magnet is an important hazard factor for beam line area, too. In this paper, bulk shielding calculations using semi-empirical formula are presented. The precise shielding design using a formula or Monte Carlo code for complicated and important structures like the front-end, synchrotron beam lines including a beam line tunnel and an experimental hutch will be carried out in near future.

The arrangement of area and environmental radiation monitoring system and personal safety interlock system were considered through safety control policy. To ensure against risks at the front-end and synchrotron radiation beam line, the beam containment system consisting of radiation detectors and an interlock system is designed. In this facility, constant property of undulator magnet (NbFeB) decides performance and lifetime of synchrotron source. It results from the demagnetization by several kinds of radiations. The radiation damage has been studied since 2000 and the results are also presented.

4. Summary

New 4th generation synchrotron facility, XFEL, is almost similar to previous 3rd generation synchrotron facility in the view of radiological aspects and most important positions are a dump and synchrotron radiation beam line. In this paper, the radiation protection solutions for them and undulator are suggested and discussed.

REFERENCES

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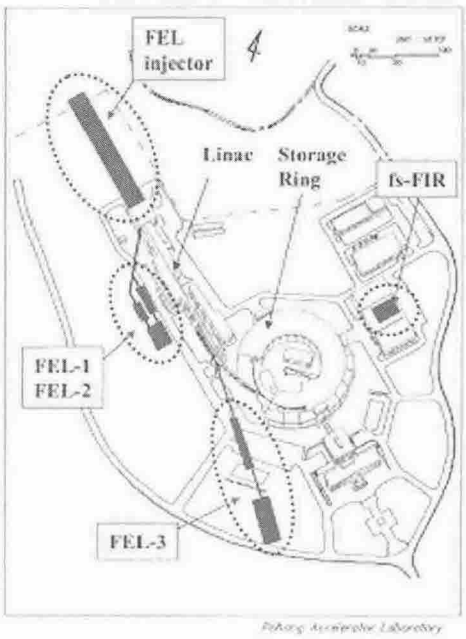

- **PAL XFEL Project**
  - Period: 2005-2009
  - Budget: 80 MS
- **femto-second FIR**
  - Energy: 40 MeV
  - Radiation: 1 ~ 20 μm
- **SASE FEL**
  - Energy: 0.7 - 3 GeV
  - FEL-1: 10~50 nm
  - FEL-2: 2 ~ 5 nm
  - FEL-3: 0.1 ~ 0.3 nm

Figure 1. Preliminary layout and main parameters of PAL XFEL.