Development of Compact Seeded Terahertz Free-Electron Laser Amplifier System at Kyoto University

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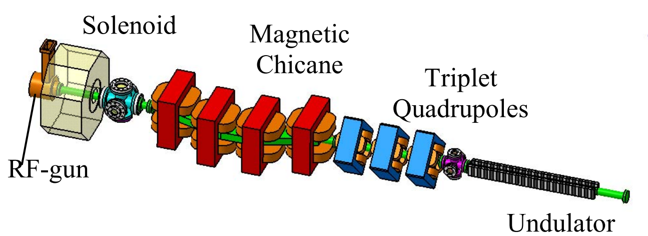
***Abstract*— We are developing a compact seeded terahertz (THz) free-electron laser (FEL) amplifier at the Institute of Advanced Energy, Kyoto University. The system consists of a photocathode RF-gun, a focusing solenoid magnet, a magnetic bunch compressor, focusing quadrupoles, an undulator, a laser system for the RF-gun and a THz parametric generator for seeding. The seeded THz lasers are amplified by FEL interaction inside the undulator. The target radiation wavelength is 300 to 800 µm. As the first step of the development, we evaluate expected power of coherent synchrotron radiations (CSRs). As the result it is found that the bunch charge from 50 to 75 pC will be suitable operation condition.**

I. INTRODUCTION

A new compact high-power THz radiation source is under construction at the Institute of Advanced Energy, Kyoto University [1]. High-brightness electron beams for the system are generated by a 1.6-cell S-band BNL-type photocathode RF-gun [2] installed with an emittance compensation solenoid magnet. Then, the electron bunch is compressed longitudinally by a 4-dipole magnetic chicane bunch compressor. A triplet quadrupole magnets is installed downstream the chicane for the electron beam matching to the undulator. A Halbach type undulator is used as a radiator. The photocathode is illuminated by a picosecond UV laser. The THz parametric generator which was developed by Nagoya University [3] will be installed as the seed laser. The system is compact with the total length less than 5 m and located in the same accelerator room with Kyoto University Free-Electron Laser (KU-FEL) [4] to share the RF-power source and the picosecond UV laser. The schematic view of the system is shown in Fig. 1.



Figures: 1. Schematic view of the compact THz-FEL amplifier system at Kyoto University.

Because the system will be operated without the seed lasers in the first stage, coherent synchrotron radiations (CSRs) from the undulator will be used to evaluate accelerator system. The total CSR energy can be estimated by a superposition of individual radiation fields of the electrons and is proportional to the square of number of electrons. The PARMELA code [5] has been used for the simulation of multi-particle beam dynamics from the RF-gun to the undulator entrance with 100,000 macro-particles. We assume that the RF-gun will be operated at the accelerating voltage of 80 MV/m and the electron beam with the average energy of 7 MeV at the laser injection phase of 14 degree will be generated.

II. RESULTS

Figure 2 shows the calculation result of the peak power of the CSR at the undulator exit. The peak power of CSR depends on the bunch charge, the bunch length, and the CSR wavelength. As the space charge effect enlarges the bunch length at a high bunch charge condition, the bunch charge from 50 to 75 pC will be a good operation point for the first stage operation.

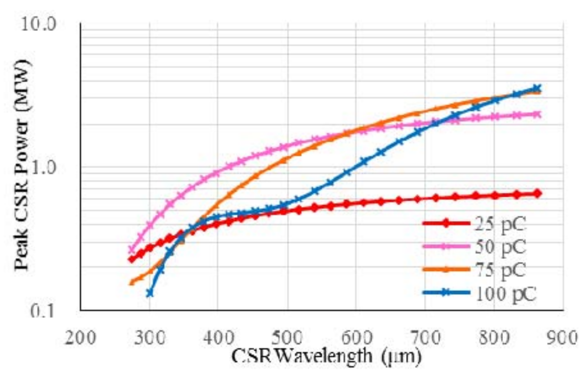


Fig. 2. The peak power of CSR at the undulator exit as a function of CSR wavelength.

III. SUMMARY

We estimate the CSR power for the first stage of the construction of the compact seeded THz-FEL amplifier system and conclude that the bunch charge from 50 to 75 pC will be a suitable operation condition. For the next steps, we will estimate the radiation performance of the seeded THz-FEL.

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