# 【Vol.2】 Report from Koichi Kan

## Study on generation of density-modulated electron beam for THz analysis of materials

Picosecond or femtosecond electron beams are useful for generation of electromagnetic waves. High-brightness electron beams are used for light sources with wavelengths such as terahertz (THz) (mid- or far- infrared) lights with free electron lasers (FELs). Generation and control of high-brightness electron beams are also studied because the quality of light source depends on the electron beam characteristics. High-power THz sources using lasers and electron beams in the THz gap between radio waves and infrared light attract many interests from viewpoints of applications and researches such nonlinear effects or structural control in material science.
Figure 1 shows schematic diagram of the proposed THz source. First, electron beam is generated in a photoinjector driven by a laser and accelerated in a linac for the electron beam energy of 50 MeV. Second, slice energy spread modulation is given in a laser modulator (LM) using THz modulation with a scheme of chirped pulse beating. In the LM, third-harmonic interaction was assumed to ease the choices of undulator parameters and modulation frequency ranging from 2 to 10 THz was considered. Momentum compaction factor of $R_{56}$ in a chicane-type bunch compressor (BC) was optimized for maximizing the bunching factor at THz frequency which is close to the initial modulation frequency. Third, density-modulated electron beam was matched for coherent undulator radiation with a matching section which was composed of two quadrupole magnets. Elegant simulation code was used for the calculation of electron beam from the LM to the exit of the matching section. The lengths of the BC, matching section, and THz undulator were assumed to be ~7 m, 2 m, and 3 m, respectively.
Figure 2 shows the bunching factor as function of the modulation frequency and momentum compaction factor of $R_{56}$ at the exit of the BC. The laser power for the LM was assumed to be 100 MW. Bunching factor is the Fourier transform of longitudinal distribution of the electron beam. High bunching factor of 0.31 was obtained at 0.59 THz. THz yield after the undulator using a theoretical estimation based on the bunching factor was found to be in the order of 100 μJ which suggests feasibilities of this high-power THz source to applications to analysis using nonlinear effects or structural control shown in material science.
Figure 3 shows a part of LCLS(Linac Coherent Light Source)-I in SLAC National Accelerator Laboratory. The linac supplies electron beam for X-ray FEL which is used for atomic and solid-state physics, chemistry, biology, medicine and so on.

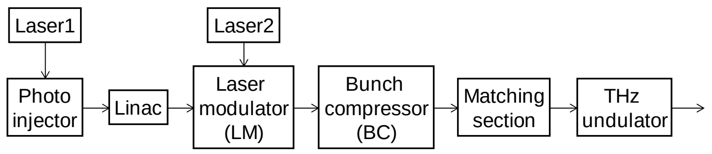


Figure 1: Schematic diagram of the proposed intense THz source driven by a compact accelerator of 35 to 50 MeV.

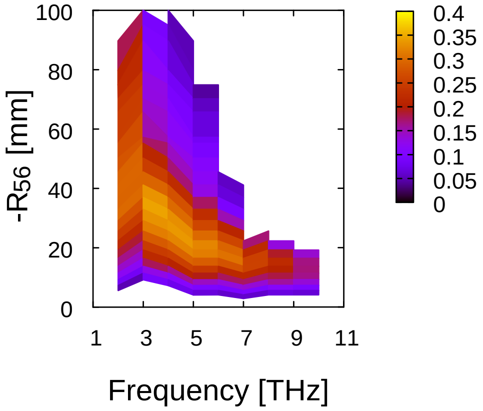


Figure 2: Bunching factor as function of the modulation frequency and $R_{56}$ at the exit of BC.

Figure 3: Picture of a part of LCLS-I.