ERL-based Laser-Compton Scattering X-ray source for X-ray Imaging

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Abstracts: *Nowadays, the generation of high brightness X-rays via laser-Compton scattering (LCS) of laser photons stored in an optical cavity by a relativistic electron beam is expected for many scientific and industrial applications such as X-ray imaging. For the demonstration of the LCS X-ray generation, it is necessary to develop a high average power laser system. The construction of compact Energy Recovery Linac (cERL) is also now in progress at KEK to generate low-emittance and high-current electron beams. In this presentation, we will show the results of the LCS X-ray generation and the X-ray imaging.*

There has been a growing interest in the laser-Compton scattering (LCS) light sources because they are capable of producing quasi-monochromatic, bright and tunable X-rays with small source size. By combining a high average power laser and an enhancement cavity with a linac, high brightness LCS X-rays can be generated. In this presentation, we will show the results of the LCS X-ray generation and the LCS X-ray imaging.

For the LCS X-ray imaging experiment, we employ a commercial passively mode-locked diode pumped solid state laser system with maximum average power of 45 W, wavelength of 1064 nm, repetition rate of 162.5 MHz, and pulse duration of 10 ps. The ejected laser beam is passed through a mode matching telescope and injected to a four-mirror enhancement cavity with two concave mirrors to produce a small spot laser beam inside a cavity. The circling intracavity power is determined by measuring the power leaking from a cavity mirror. From this measurement, when the injection power was 24 W, a circulating power of 10.4 kW was obtained.

The cERL is a superconducting test accelerator to demonstrate both low-emittance and high average current operation in an energy recovery linac. The electron beam with bunch charge of 0.36 pC and bunch length of 3 ps was accelerated to 20 MeV and was transported to the collision point. The laser pulses and electron beam must be synchronized to achieve collision. This synchronization is realized with a Hänsch-Couillaud method and a phase locked loop method.

In the LCS X-ray generation experiment, around 7 keV X-ray was generated by collision of 1064 nm laser photons and 20 MeV electrons at an angle of 18 deg. A silicon drift detector (SDD) used for the LCS X-ray observation was placed 16.6 m from collision point. The central energy of 6.91 keV, the FWHM spectrum width of 0.173 keV and detector count rate of 1200 cps was obtained within a detector area, ϕ4.66 mm. From this measurement, the LCS photon flux at the collision point is estimated to be 4.3 x 10^7 photons/sec. We also performed the high contrast X-ray imaging of a hornet by using a 2D photo counting X-ray detector. From the obtained imaging, we confirmed that LCS X-rays from a small source size are useful for phase-contrast X-ray imaging.