# Light Source Developments by Using Relativistic Electron Beams


## UVSOR Facility
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UVSOR is a synchrotron light source to provide low energy synchrotron light ranging from terahertz wave to soft X-rays. Although it was constructed about 30 years ago, its performance is still in the world top level. This is the result of the continuous effort on improving the machine. Our research group has been developing accelerator technologies toward producing bright and stable synchrotron light, such as high brightness electron beam optics, novel insertion devices or state-of-the-art beam injection technique. We have been also developing novel light source technologies toward producing synchrotron radiation with various characteristics such as free electron laser, coherent synchrotron radiation and laser Compton gamma-rays. We are also investigating future light sources for the facility, such as a diffraction limited light source or a linac-based free electron laser source.

**Figure 1.** UVSOR-III Electron Storage Ring and Synchrotron Radiation Beamlines.

## Selected Publications


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- Y. Taira, H. Toyokawa, R. Kuroda, N. Yamamoto, M. Adachi, S. Tanaka and M. Katoh, "Photon-Induced Positron Annihilation Lifetime Spectroscopy Using Ultrashort Laser-Compton-Scattered Gamma-Ray Pulses," *Rev. Sci. Instrum.* **84**, 053305 (2013).

## 1. Light Source Technology Developments Based on Laser and Synchrotron

We have developed novel light source technologies using UVSOR-III electron storage ring and external laser sources. Under the support of Quantum Beam Technology Program of JST/MEXT, a new experimental station dedicated for the source development studies were constructed. We modified a part of the accelerator to produce a space for new undulator system and dedicated beam-lines. The generation of coherent synchrotron radiation based on our original method was successfully demonstrated at the new site, in collaboration with Lille Univ. and Nagoya Univ. For the applications using coherent synchrotron radiation, the construction of the beam-line is in progress. Some basic researches on the optical vortex beam from helical undulators are in progress in collaboration with Hiroshima Univ. and KEK.

Laser Compton scattering is a method to produce monochromatic and energy-tunable gamma-ray pulses. Laser pulses are injected to the storage ring and are scattered by the relativistic electrons circulating in the ring. We developed a unique method to produce ultra-short gamma-ray pulses in pico- and femtosecond range for the first time and demonstrated its potential as a powerful tool for material sciences by a photon-induced positron annihilation lifetime spectroscopy experiment, in collaboration with AIST. We have started developing an imaging technology for isotopes based on nuclear fluorescence resonance in collaboration with Kyoto Univ., AIST and JAEA. We have succeeded in producing intense gamma-ray beam by using a fiber laser. We have started reconstructing the resonator free electron laser on UVSOR-III, which will be used to produce intense gamma-rays through intra-cavity inverse Compton scattering.

**Figure 2.** Twin Polarization-variable Undulators/Optical Klystron at UVSOR-III.

## 2. Accelerator Technology Developments for Synchrotron Light Source and Free Electron Laser

The UVSOR facility has been operational as a national synchrotron light source for lower energy photons from the terahertz wave to the soft X-rays. The machine was born as a low energy second generation light source and now it is 30 years old. We have proposed several upgrades and most of them have been carried out successfully. We designed a special electron beam optics intended to higher brightness. We designed accelerator components necessary for the new optics and have successfully remodeled and commissioned the machine with the new optics. We have designed six undulators and have successfully installed and commissioned all of them. We have succeeded in introducing a novel operation mode called Top- up operation, in which the electron beam intensity is kept quasi-constant at a high beam current, 300 mA. As the result of all these efforts, now, the machine is the brightest synchrotron light sources among the low energy machines below 1 GeV in the world.

We continue the efforts to improve the machine performance by using new technologies such as pulsed sextupole injection scheme. Also, we are designing new accelerators for future project of the facility, such as linear accelerator based free electron laser or diffraction limited storage ring light source. As a technology development towards the new facility, a superconducting RF electron gun has been developed in collaboration with KEK, which would produce high brightness electron beam with high repetition rate.


**Figure 3.** Optical Cavity for Resonator Free Electron Laser is under reconstruction at UVSOR-III.

### Award

ITO, Kenya; 2015 Annual Meeting Award of the Particle Accelerator Society of Japan.

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