

Light Source Developments by Using Relativistic Electron Beams

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Keywords Accelerator, Beam Physics, Astrobiology

UVSOR is a synchrotron light source providing 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 photons with excellent properties, such as free electron laser, coherent synchrotron radiation and laser Compton gamma-rays. We are also investigating beam physics which would be the basis of the novel light source technologies. We are exploring a future plan for the facility, such as a diffraction-limited storage ring or a free electron laser facility.



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

Selected Publications

- S. Bielawski, C. Evain, T. Hara, M. Hosaka, M. Katoh, S. Kimura, A. Mochihashi, M. Shimada, C. Szwaj, T. Takahashi and Y. Takashima, "Tunable Narrowband Terahertz Emission from Mastered Laser-Electron Beam Interaction," *Nat. Phys.* **4**, 390–393 (2008).
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1. Light Source Technology Developments Based on Laser and Synchrotron

We have developed novel light source technologies using UVSOR-III electron storage ring and a dedicated experimental station BL1U which was constructed under the support of Quantum Beam Technology Program of JST/MEXT, for developing novel light sources and exploring their applications. The BL1U is equipped with two undulators which constitute an optical klystron, a laser system which is synchronized with the accelerator beam and a dedicated beam-line. The generation of coherent synchrotron radiation based on our original method was successfully demonstrated in collaboration with Lille Univ. and Nagoya Univ. Its application is under preparation, in collaborating with Osaka Univ. Optical vortex beam from undulators are intensively investigated in collaboration with Hiroshima Univ., Nagoya Univ., AIST and so on.

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 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

We proposed several upgrade plans and have carried out all of them successfully. We designed a special electron beam optics intended to higher brightness. We designed necessary accelerator components, remodeled the machine and commissioned. 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 introducing new technologies such as pulsed sextupole injection scheme. We are planning to replace some of the undulators to fit the changes of the users' requirements. 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.

We are collaborating with Nagoya University Synchrotron Radiation Research Center (NUSR) for the accelerator developments at Aichi-SR. Accelerator magnets based on permanent magnets are being developed. Various electron sources are being developed and tested. New beam diagnostic technologies are being tested. Several PhD students from the University are involved. We are also collaborating with Accelerator Research Laboratory at KEK for the compact Energy Recovery Linac (cERL) project.



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

Award

YAMAGUCHI, Kenta; 2016 Annual Meeting Award of the Particle Accelerator Society of Japan.

* carrying out graduate research on Cooperative Education Program of IMS with Nagoya University