

PROGRESS IN R&D EFFORTS ON THE ENERGY RECOVERY LINAC IN JAPAN

S. Sakanaka, T. Agoh, A. Enomoto, S. Fukuda, K. Furukawa, T. Furuya, K. Haga, K. Harada, S. Hiramatsu, T. Honda, Y. Honda, K. Hosoyama, M. Izawa, E. Kako, T. Kasuga, H. Kawata, M. Kikuchi, H. Kobayakawa, Y. Kobayashi, T. Matsumoto, S. Michizono, T. Mitsunashi, T. Miura, T. Miyajima, T. Muto, S. Nagahashi, T. Naito, T. Nogami, S. Noguchi, T. Obina, S. Ohsawa, T. Ozaki, H. Sasaki, S. Sasaki, K. Satoh, M. Satoh, M. Shimada, T. Shioya, T. Shishido, T. Suwada, T. Takahashi, Y. Tanimoto, M. Tawada, M. Tobiyama, K. Tsuchiya, T. Uchiyama, K. Umemori, S. Yamamoto

High Energy Accelerator Research Organization (KEK), Oho, Tsukuba, Ibaraki 305-0801, Japan

R. Hajima, H. Iijima, N. Kikuzawa, E. J. Minehara, R. Nagai, N. Nishimori, M. Sawamura
Japan Atomic Energy Agency (JAEA), Tokai, Naka, Ibaraki 319-1195, Japan

N. Nakamura, A. Ishii, I. Ito, T. Kawasaki, H. Kudoh, H. Sakai, T. Shibuya, K. Shinoe, T. Shiraga, H. Takaki

Institute for Solid State Physics (ISSP), University of Tokyo, Kashiwa, Chiba 277-8581, Japan

M. Katoh

UVSOR Facility, Institute for Molecular Science, Myodaiji-cho, Okazaki, Aichi 444-8585, Japan

M. Kuriki

Hiroshima University, Kagamiyama, Higashihiroshima, Hiroshima 739-8530, Japan

D. Yoshitomi, Y. Kobayashi, K. Torizuka

National Institute of Advanced Industrial Science and Technology (AIST)
Umezono, Tsukuba, Ibaraki 305-8568, Japan

H. Hanaki

JASRI/SPring-8, Kouto, Sayo-cho, Sayo-gun, Hyogo 679-5198, Japan

Abstract

Future synchrotron light sources based on the energy-recovery linacs (ERLs) are expected to be capable of producing super-brilliant and/or ultra-short pulses of synchrotron radiation. Our Japanese collaboration team is making efforts for realizing an ERL-based hard X-ray source. We report recent progress in our R&D efforts.

INTRODUCTION

Along with mature performance of ring-based synchrotron light sources, the energy-recovery linacs attract our attention as very promising new light sources which can overcome the limitations of ring-based sources. The ERL-based light sources are expected to be capable of producing super-brilliant and/or ultra-short pulses of synchrotron radiation. They are also expected as promising drivers for oscillator-type X-ray free electron lasers [1]. The ERL-based hard X-ray sources are seriously considered at the Cornell University [2], at the Argonne National Laboratory [3], and at KEK/JAEA [4]. The ERLs are also expected as intense electron drivers for

cooling ion beams, and serious R&D programs are being conducted at the Brookhaven National Laboratory [5] and at the Jefferson Laboratory [6].

We are aiming at realizing an ERL-based hard X-ray source in Japan, and are conducting R&D efforts. We are currently developing such key components as: (i) photocathode DC guns which are capable of producing ultra-low emittance, high-current beams, (ii) drive lasers for the gun, (iii) both superconducting cavities for the injector linac and for the main linac. We also plan to assemble these key components into the Compact ERL [7], and to demonstrate their operations.

ELECTRON GUN

An electron gun to generate electron beams of high-brightness and high-average current is one of the most essential components for the ERL light source. We employ a photocathode DC gun for the ERL. A 250-kV, 50-mA gun has been developed at JAEA. The gun has been almost assembled and the first photo-current was obtained from a cathode of NEA-GaAs. Apparatuses for

the both warm end and cold ends of a 60-Ω coaxial antenna coupler. Figure 5 shows a schematic drawing of our test stand for the rf-windows.

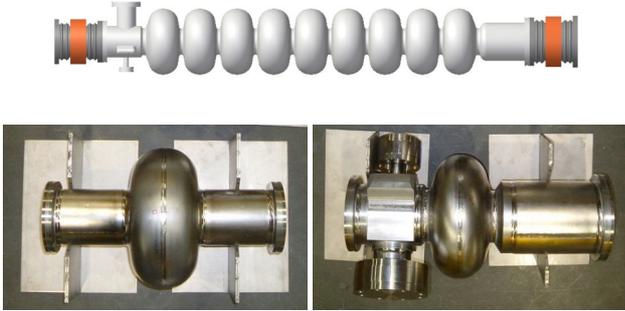


Figure 3: A sketch of the KEK-ERL 9-cell cavity (upper), and two test cavities, C-single (left) and E-single (right).

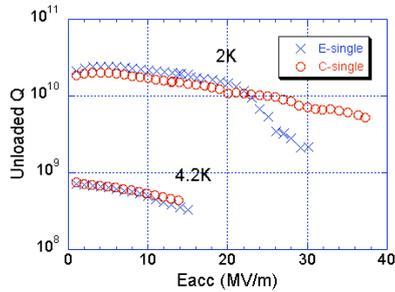


Figure 4: Result of the vertical tests of single-cell cavities.

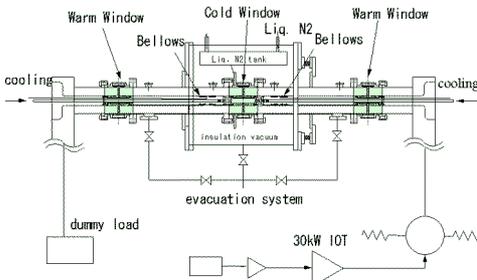


Figure 5: Schematic drawing of a coupler test stand.

DESIGN OF THE COMPACT ERL

We have completed a conceptual design [7] of the Compact ERL, which is a test facility planned to be built at KEK. The plan of the Compact ERL is shown in Fig. 6. Table 3 shows the principal parameters of the Compact ERL, together with those of the ERL-based future light source. The primary purpose of the Compact ERL is to demonstrate reliable operations of the key components, as well as to investigate accelerator physics issues that are critical to build the ERL for the light source.

The Compact ERL can also be used as: (i) an intense terahertz-radiation source using the coherent synchrotron radiation (CSR), and (ii) an ultra-short or a high-intensity X-ray source using Compton backscattering with laser pulses. We anticipate a photon flux density of about 10¹⁷

photons/s/mrad²/0.1%b.w. [16] at the photon energy of about 10 meV (~2.4 THz) from compressed bunches having pulse widths of 59 fs (rms) at the beam energy of 155 MeV. The Compact ERL can also provide ultra-short X-ray pulses having the pulse widths of about 110 fs. With the 90° Compton-backscattering configuration, we anticipate a photon flux of 3.5×10³ photons/pulse/3%b.w. [7] at the beam energy of 60 MeV, the bunch charge of 100 pC, and the laser pulse of 10 mJ/pulse.

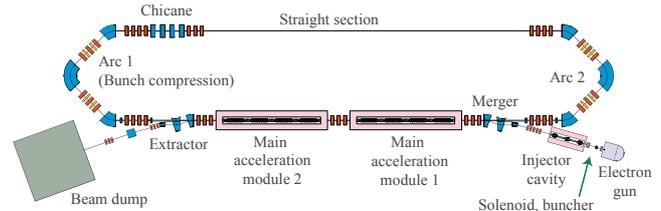


Figure 6: Plan of the Compact ERL.

Table 3: The principal parameters of the Compact ERL and the ERL-based future light source.

	Compact ERL	Light source	
Beam energy	0.065-0.2	5	GeV
Injection energy	5	~10	MeV
Path length	70	1253	m
Beam current	10-100	10-100	mA
Charge per bunch	7.7-77	7.7-77	pC
Normalized emittance	0.1-1	0.1-1	mm-mrad
Bunch length (rms)	0.1-3	0.1-3	ps

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