# 2 3-GeV ERL Design

The future ERL-based light source consists of a 3-GeV ERL and an XFEL-O. A conceptual view of the project and the target parameters are given in Ref. [1]. The 3-GeV ERL provides super-bright and/or ultra-short synchrotron radiation (SR) in the vacuum ultra-violet (VUV) to hard X-ray range, and the XFEL-O provides fully coherent radiation. In XFEL-O operation, an electron beam is accelerated twice by the superconducting main linac of the ERL without energy recovery and transported to the XFEL-O after acceleration up to 6 – 7 GeV.

Figure 1 shows the preliminary result of the optical functions for the main linac and the return loop of the 3-GeV ERL. In the design, the injection energy is assumed to be 10 MeV. The main linac consists of more than 200 super-conducting (SC) 9-cell cavities, each of which has a moderate accelerating field of less than 15 MV/m to suppress field-emitted electrons causing beam halo and radiation hazards. Quadrupole triplets are placed at every eighth SC cavity for horizontal and vertical focusing. The optics of the main linac is mirror-symmetric for acceleration and deceleration and designed so that the betatron function is well suppressed for achieving a high BBU (beam breakup) threshold current. The return loop of the 3-GeV ERL has 28 TBA (Triple Bend Achromat) cells with 22 × 6-m and 6 × 30-m long straight sections for insertion devices. The bending radius of the bending magnet is sufficiently long and as a result the increase in emittance growth and energy spread due to incoherent SR are negligibly small for both ERL and XFEL-O modes. A bunch compression scheme for generating ultra-short SR pulses and a path-length control system for switching from ERL to X-FELO operational modes should be studied and added. Figure 2 shows the tentative layout of the ERL-based light source on the KEK Tsukuba campus.

Figure 3 shows examples of the calculated spectral brightness for VUV-SX (soft X-ray) and X-ray undulators. As shown in this figure, the 3-GeV ERL can provide undulator radiation with maximum spectral brightness of $10^{22}$ – $10^{23}$ phs/s/mm$^2$/mrad$^2$/0.1%b.w. The 6-7 GeV XFEL-O generates spatially and temporally coherent X-rays with brightness greater than $10^{26}$ phs/s/mm$^2$/mrad$^2$/0.1%b.w. For future development, a 300-m long straight section is reserved in the middle of the return loop. This section has major potential for (1) EEHG (Echo-Enabled Harmonic Generation) including attosecond pulse generation, (2) 3-GeV XFEL-O using the higher harmonics, and (3) a very long undulator with spectral brightness up to $10^{23}$ – $10^{24}$ phs/s/mm2/mrad2/0.1%b.w.

## REFERENCE

[1] “Energy Recovery Linac Conceptual Design Report”, KEK Report 2012-14,
http://ccdb5fs.kek.jp/tiff/2012/1224/1224004.pdf

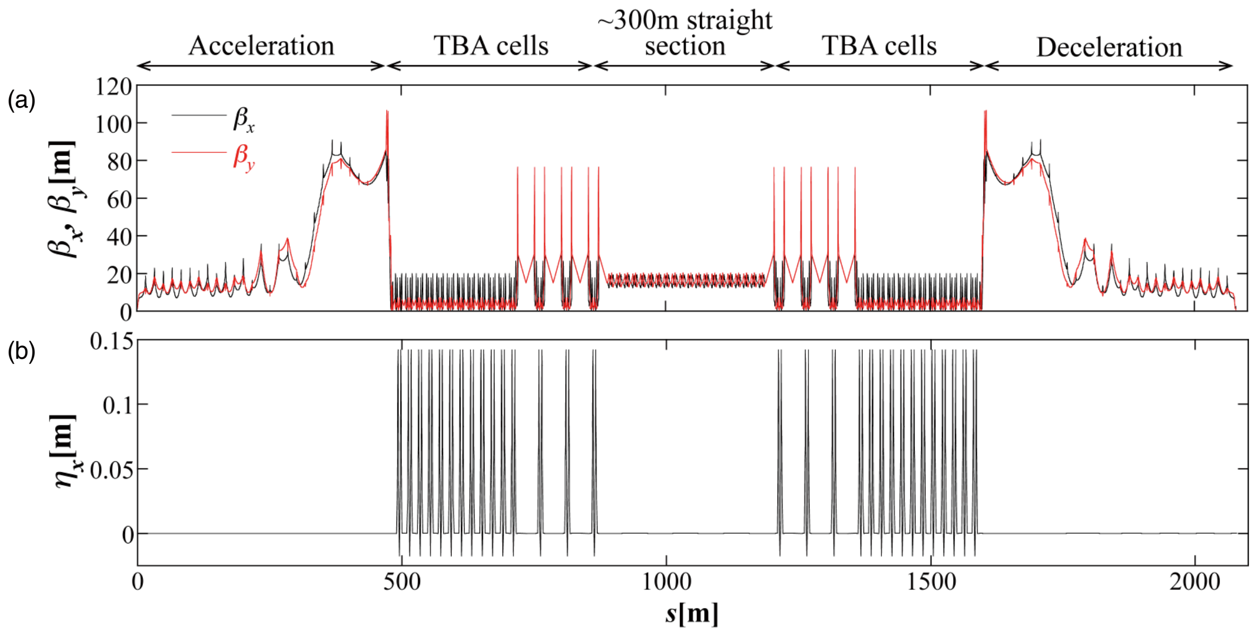


Figure 1: Betatron (a) and dispersion (b) functions of the main linac and the return loop for the 3-GeV ERL.

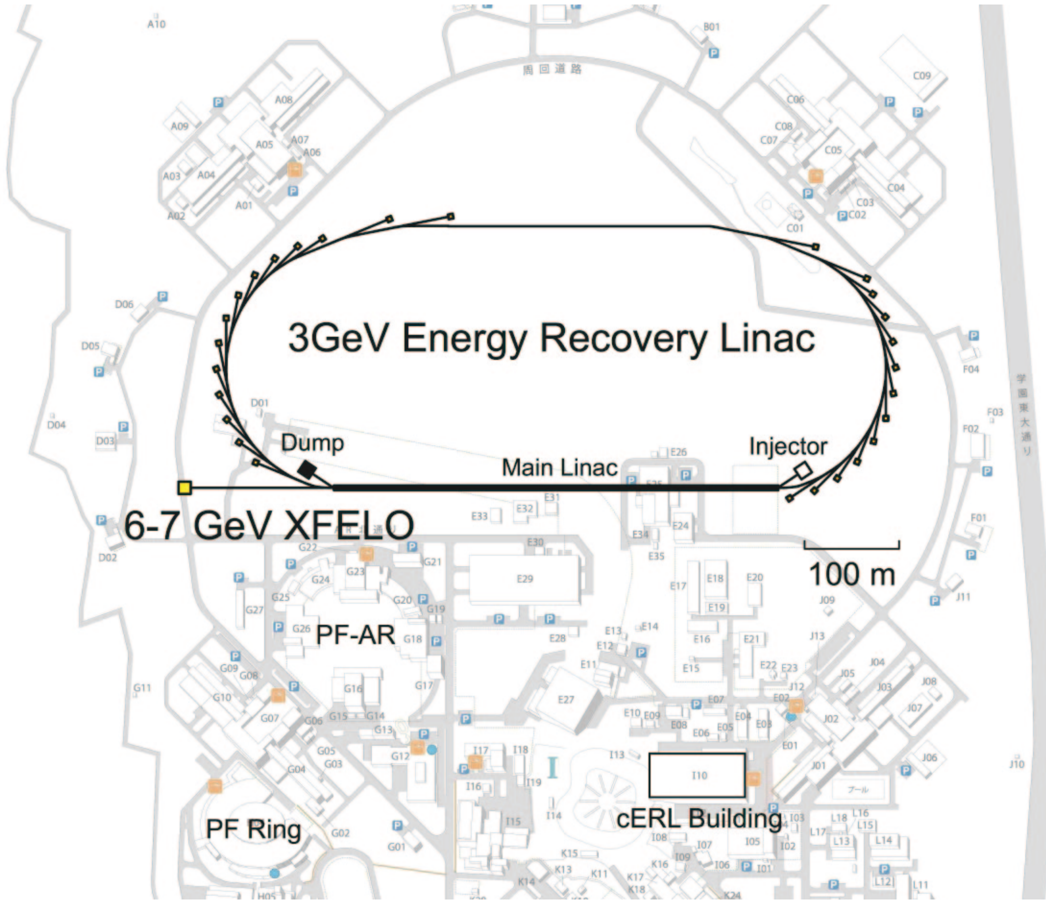


Figure 2: Tentative layout of the ERL-based light source at KEK Tsukuba campus.

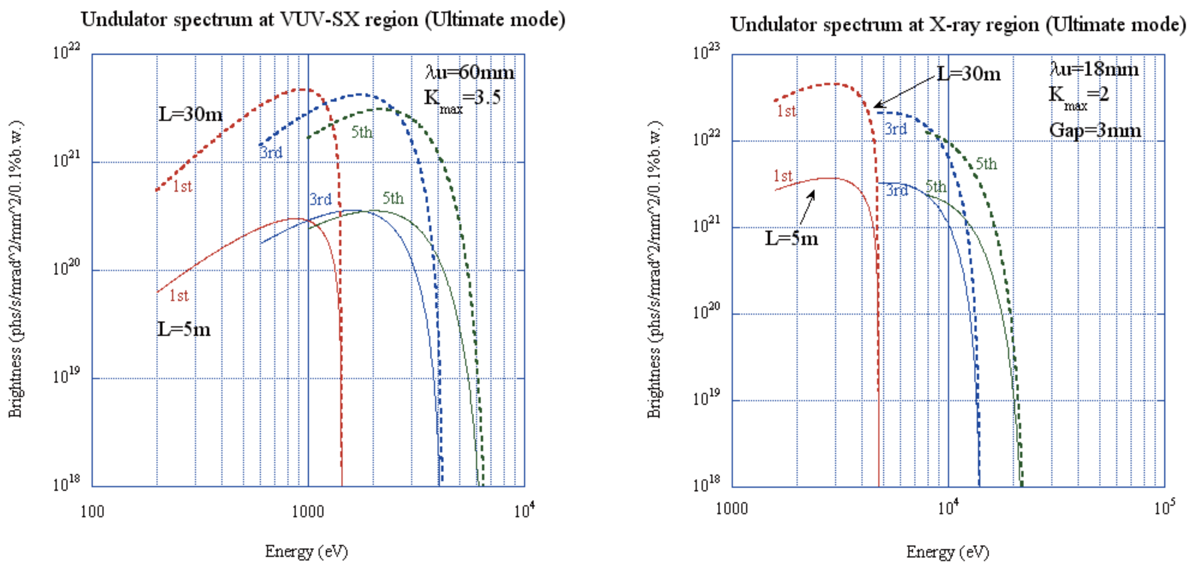


Figure 3: Examples of calculated spectral brightness for VUV-SX and X-ray undulators