The Stretcher Operation of KSR

Takashi Sugimura, Akio Morita, Hiromu Tonguu, Toshiyuki Shirai, Yoshihisa Iwashita, Hirokazu Fujita and Akira Noda

The electron ring KSR has been utilized as a pulse stretcher of the 100 MeV S-band electron linac. The duty factor of the electron beam has been increased drastically more than 90% from 2×10^{-5}.

Keywords: electron ring/ KSR/ slow extraction/ RFKO/ duty factor

An S-band electron linac with the maximum energy of 100 MeV has been operated since October 1995. This linac has been used for experiments such as Parametric X-Ray radiation from the crystal and resonant transition radiation from the foils of dielectric substance. The pulse width and the repetition rate of the linac, however, are limited at 1μsec and 20Hz, respectively, which results in the beam duty factor of 2×10^{-5} at maximum. In order to avoid the pile up of the signals from the detectors, we are forced to reduce the peak current of the output beam from the linac, which causes reduction of the average current. So the idea of using the KSR as a pulse stretcher was proposed so as to improve this situation, while KSR is also to be utilized as a synchrotron light source with the maximum energy of 300 MeV[1,2]. The total layout of KSR is shown in Figure 1, where main devices for beam injection and extraction are indicated.

In the stretcher mode, the electron beam from the linac is injected into the ring through the inflector and extracted from the ring through the electrostatic septum (ESS) with the repetition rate of 1 Hz[3]. After the injection, the transverse RF electric field resonating with the betatron oscillation is applied in the horizontal direction (RF knock out, RF-KO). The stable beam with small amplitude is driven to the separatrix, which is the boundary between the stable and unstable regions for the third order resonance in the horizontal transverse phase space. The beam becomes unstable and its amplitude increases as shown in Figure2 along the branches of the separatrix. With this method, the separatrix is fixed throughout the whole process and the direction of the extracted beam

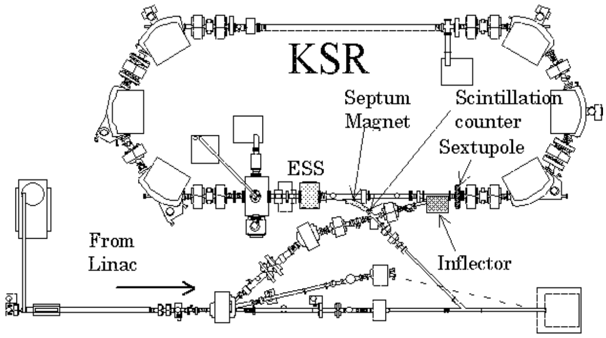

Figure 1. The layout of the KSR. Main devices for the beam injection and extraction are shown.

NUCLEAR SCIENCE RESEARCH FACILITY — Particle and Photon Beams —

Scope of research

Particle and photon beams generated with accelerators and their instrumentations both for fundamental research and practical applications are studied. The following subjects are being studied: Beam dynamics related to space charge force in accelerators: Beam handling during the injection and extraction processes of the accelerator ring:radiation mechanism of photon by electrons in the magnetic field: R&D to realize a compact proton synchrotron dedicated for cancer therapy: Control of the shape of beam distribution with use of nonlinear magnetic field: and Irradiation of materials with particle and photon beams.

Prof
NODA, Akira
(D Sc)

Assoc Prof
IWASHITA, Yoshihisa
(D Sc)

Instr
SHIRAI, Toshiyuki

Techn
TONGUU, Hiromu

Lecturer(part-time):
NAKAJIMA, Kazuhisa(KEK)
Students:
SUGIMURA, Takashi(DC)
KIHARA, Takahiro (DC)
URAKABE, Eriko (DC)
MORITA, Akio (DC)
NAKAMURA, Syu(MC)
FADIL, Hicham(MC)
YAMAZAKI, Atsushi(RS)

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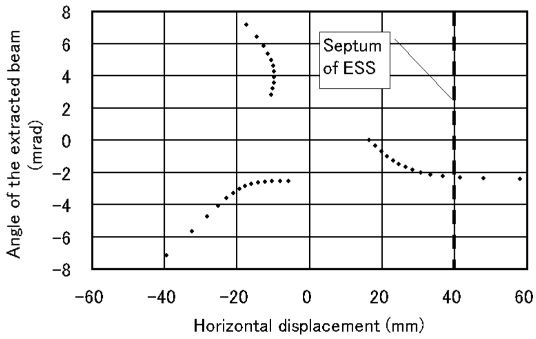

Figure 2. Phase space plot of the beam at the entrance of ESS.

does not change, while the ordinary method, so far utilized, reduces the separatrix size, which inevitably results in the variation of the extracted beam direction. The turn separation, which is the amplitude increase of betatron oscillation in 3 turns, is estimated to be 3.2 mm in the present case and the extraction efficiency is calculated to be 97% for the extraction system using the electrostatic septum with septum thickness of 0.1 mm.

The extraction channel consists of two devices. One is the Electrostatic septum and the other is a magnetic septum (see Figure 3,4).

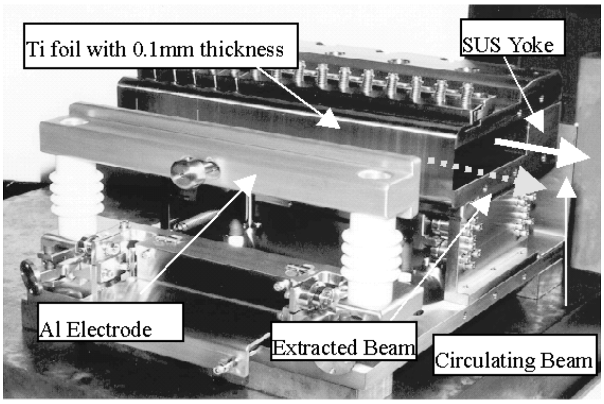

Figure 3. The electrostatic septum. The circulating beam passes through the inside of the yoke, and the beam exceeding 40mm in its oscillation amplitude is deflected outward by 20.5 mrad with the electric field applied between the Ti foil and the Al electrode, and then guided to the septum magnet located downstream.

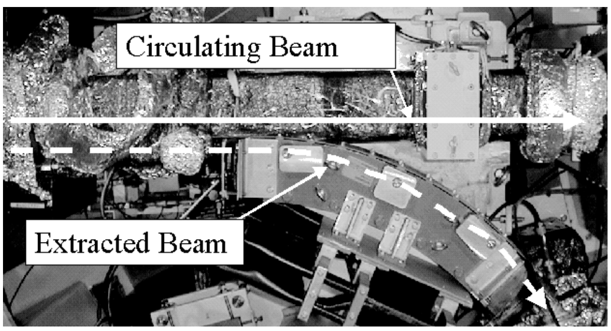

Figure 4. The magnetic septum.After the deflection of the ESS, septum thickness of 22.6 mm is provided for the septum magnet. With the field of 0.5T and the pole length of 550 mm the extracted beam is deflected as large as 45° and is guided to the extraction beam line.

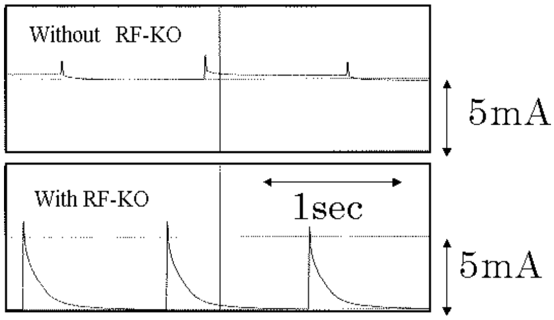

Figure 5. Output signal of the DCCT. The axes of abscissa and ordinate are time and the circulating beam current in KSR,respectively. Without RF-KO, the circulating beam does not decrease. With RF-KO, circulating beam decreases slowly with extraction procedure.

Observations of a beam current in the ring and an extracted beam spill were performed with the beam energy of 80 MeV. Figure 5 shows the output signal of the DCCT (DC current transformer) with and without RF-KO. This figure shows that the beam current in KSR decreases slowly by RF-KO. A scintillation counter was set just after the exit of the magnetic septum as shown in Figure 1 and the extracted beam was measured. Figure 6 shows the first measurement of the pulse rate of scintillation counter for the first 800 ms. It was confimed that the beam extraction continues during almost 1sec after the injection.

The stretcher ring KSR utilizing the slow extraction with an RF-KO and the third order resonance is found to work as designed. This is the first slow extraction experiment with this scheme for the electron beam under the radiation damping.

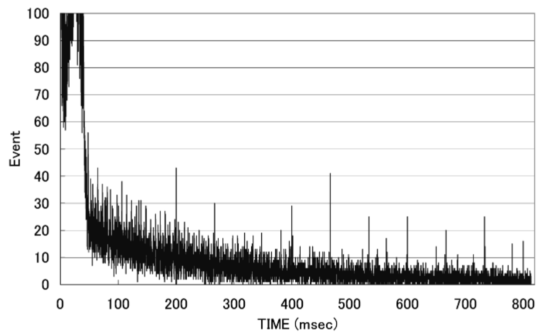

Figure 6. Pulse rate of the extracted beam. A background has been subtracted. The further fine tuning is required to realize the flat beam spill.

References

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