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LOSS MONITOR SYSTEM FOR THE JAERI SUPERCONDUCTING RF LINAC-BASED FEL

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Abstract

In order to reduce substantially high radiation level of X- and gamma-rays at the JAERI FEL facility, we have developed a beam current loss monitoring system being distributed along the beam line of the JAERI Superconducting rf Linac. Preliminary and experimental results showed the reduction of about a few orders of magnitudes in the JAERI FEL experimental hall. Design options of the photon detectors and monitoring ways are reported briefly.

原研超伝導リニアックFELにおけるビームロスモニターシステム

In order to decrease substantially the hard X- and gamma-rays radiation level at the JAERI FEL facility, we have developed a beam current loss monitoring system being distributed along the beam line of the JAERI superconducting rf linac. Usually, we first try to maximize a transmission of an electron beam through the rf linac by adjusting beam optical elements, and by monitoring the beam current. Once we succeed to transport the electron beam with about a full transmission, and we can not use a current monitor system to reduce a smaller amount of the beam loss than a few %. In order to reduce the beam loss smaller than 0.01% or less, we have to use a more sensitive monitor for the current loss than the current monitor.

Preliminary and experimental results showed the reduction of about one and half orders of magnitudes in the JAERI FEL experimental hall. Plastic, NaI(Tl) crystal and Glass scintillators have been used to reduce the radiation level. In order to monitor the radiation level induced by an electron beam loss, we have developed a new semiconductor radiation monitor using a Si-photo diode[1)], CsI or BGO scintillators and a charge-sensitive hybrid amplifier[2)]. In a heavy radiation circumference, we used to remove the scintillation crystal or glass to reduce the monitor sensitivity, and reduce the bias voltage. Design options of the photon detectors and monitoring ways will be discussed.

In the Fig.1, a typical pulse shape from the loss monitor prototype of Si-photo diode is shown to have a rise time of 30μs and a fall time of about one hundred μs. The rise time is the same with a beam pulse duration, and the fall time an amplifier time constant. In the case of the short pulse duration or gamma ray source, the rise time is the same with the circuit rise time, and less than 1μs. The pulse is taken about 2 meters after the JAERI superconducting rf-linac based FEL driver along the beam line. The monitor was fixed at the position of about one and half meter from the stainless-steel beam duct, and heavily-shielded with several 50mm-thick Pb blocks on the floor. In the Fig.2, 2.5ms and 30 μs duration components are shown in a typical loss monitor pulse under beam acceleration. The long is the same with an rf pulse length of the linac, the short macro pulse. The long comes from the X-rays being originated from the field-emitted electron bombardment, the short the electron beam loss.

References

1) Hamamatsu Photonics Co. "Si PIN Photo diode S3590-05".

2) Hamamatsu Photonics Co. "a charge-sensitive hybrid amplifier H4083".

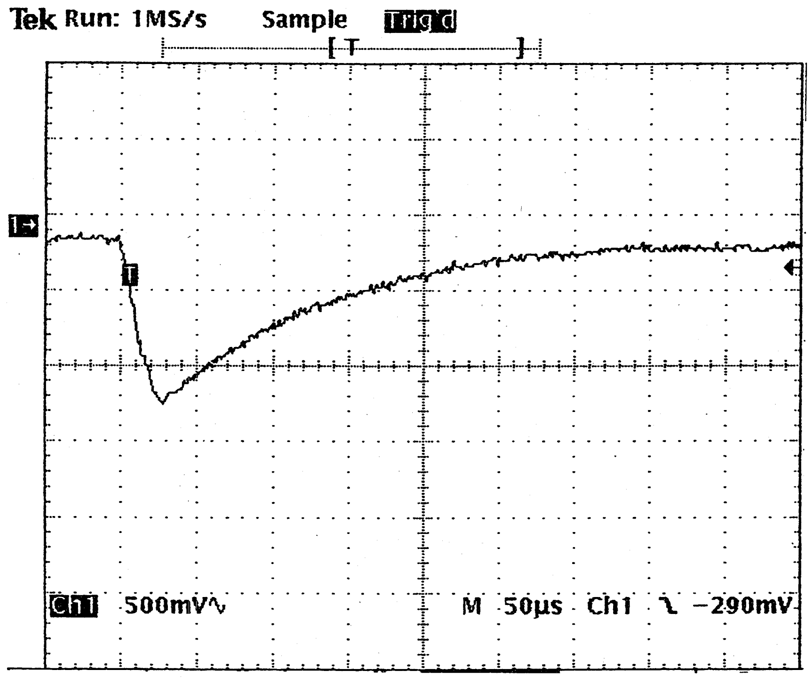

Fig.1: A typical pulse shape from a loss monitor prototype of Si-photo diode is shown, and has a rise time of 30μs and a fall time of about a few hundreds μs.

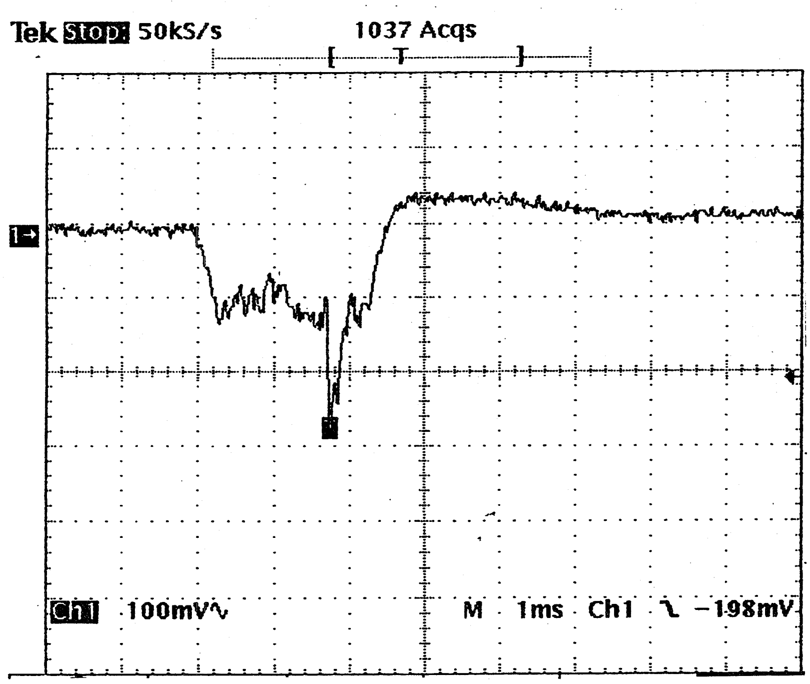

Fig.2: Long and short duration components in the typical loss monitor output under beam acceleration. The long one is 2.5ms long, the short 30μs long. The long comes from the X-rays being originated from the field-emitted electron bombardment during the RF macro pulse, the short the electron beam loss.