Calibration of the beam energy position monitor system for the RIKEN superconducting acceleration cavity†

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Upgrades for the RIKEN Heavy-ion Linac that involve a new Superconducting Linac (SRILAC) are currently underway to promote super-heavy element searches and the radioactive isotope (RI) production of astatine (^{211}At) for medical use.[1,2] We have developed a beam energy position monitor (BEPM) system[3] that can simultaneously measure not only the beam position but also the beam energy by measuring the time of flight of the beam. By using parabolic-shaped electrodes (Fig. 1), we realized the ideal linear response of the quadrupole moments while maintaining good linear position sensitivity. We fabricated 11 BEPMs and a position calibration system employing the wire method that we used to obtain the sensitivity and offset of the BEPMs.

Destructive monitors generate outgassing; if they are used, it becomes difficult to maintain the Q value and surface resistance of the superconducting radio frequency (SRF) cavities over a long period of time. It is, therefore, crucial to develop nondestructive beam measurement diagnostics. With the aim of measuring the beam position at an overall accuracy of ± 0.1 mm, a calibration measurement was performed at the KEK campus in Tokai.

Because there are 3 types of BEPMs for the SRILAC,[3] we designed and fabricated dummy pipes that surround the wire and jigs to mechanically fit the calibration device. The calibration device is shown in Fig. 2. The BEPM to be calibrated is connected to a dummy pipe with an inner diameter equal to that of one of the BEPMs (Fig. 2(a)). The assembly is fixed to an XY stage that moves within the measurement region in 2-mm steps. A wire acting as a signal source is fixed. Round crimp terminals are attached by crimping and soldering at both ends of a copper-plated piano wire. The dummy duct has a double-pipe structure that can be expanded and contracted. When the round-crimp terminals are connected to the electrode on both end plates, the inner dummy pipes are made to slide into the outer dummy pipe to provide sufficient space for the connection of the electrodes. After that operation is completed, the inner dummy pipes are restored to their original position and fixed to the double pipe by fastening bands. Adequate tension can be applied by moving one of the end plates outward with fine adjustment. The dummy pipes are connected to the end plates with an RF contact finger and are held to the ground potential (Fig. 2(b)). When the measurement was repeated, it was found that both the required electrical characteristics and flexibility could be achieved simultaneously by reducing the number of RF contact fingers and applying copper tape to the end plates. As a result, measurement errors were drastically reduced.

By using the calibration device, the calibration was completed to within ±0.05 mm mechanical accuracy. We will continue to analyze the measurement results of all the BEPMs, which will be used to measure the beam position and energy using the calibration values when the beam is accelerated at SRILAC.

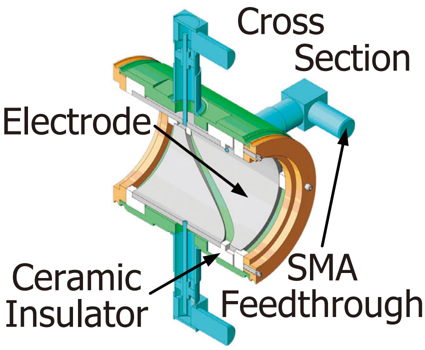

Fig. 1. Parabolic-shaped electrodes.

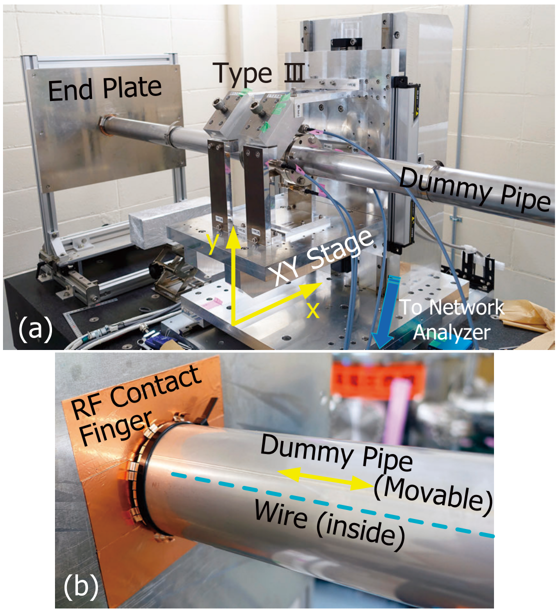

Fig. 2. Photographs of the calibration measurement device, jigs, and dummy pipes.

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