Beam energy adjuster for super-heavy element synthesis at RIKEN Ring Cyclotron

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A new experiment on the synthesis of super-heavy element (SHE) is on going in the RIKEN Nishina Center using a vanadium beam[1)] accelerated by the combination of RIKEN Linear Accelerator 2 (RILAC2)[2,3)] and RIKEN Ring Cyclotron (RRC).[4)] For the SHE experiment, the beam energy has to be adjusted to the pinpoint value that continuously irradiates to a target over a long period. However, it is difficult to flexibly change the beam energy by the cyclotron. Therefore, we introduced a beam energy adjuster (BEA) using an acceleration cavity into the beam line from the RRC to the target to ensure that the beam energy can be finely adjusted to approximately ± 3%.

We decided to divert the final-stage acceleration cavity, RF power amplifier, and the control system used as RILAC booster[5)] to the BEA system. This acceleration cavity is a 6 gap quarter-wavelength resonator. Although the cell length does not perfectly match with the velocity of the beam from the RRC, the original layout of the drift tubes was applicable to the fine adjustment of the beam energy. Because the original resonant frequency of the cavity was 75.5 MHz, it was remodeled to 73.0 MHz, which was compatible with the operation frequency of the RRC. To lower the resonant frequency, the outer and inner cylinders were extended by inserting an outer spacer ring and an inner spacer ring, respectively. Both spacer rings were made of oxygen-free copper. The height of both rings was 36 mm, as determined by 3D electromagnetic calculation using Microwave Studio (MWS). Figure 1 shows the calculation model of MWS with the spacers.

The original cavity was transferred to the beam-distribution corridor (D-corridor) in the Nishina Memorial building in the summer of 2017.[6)] After the spacer rings were attached to the cavity, a low-power RF test was performed in October. Figure 2 shows the inner cylinder of the BEA cavity after inserting the spacer ring. The test result indicated that it was successfully remodeled to have a resonant frequency of 73.0 MHz with a quality factor Q_0 of 22500, which was almost equivalent to the original cavity. The control system, vacuum system, cooling water, and control cables were installed simultaneously. Finally, the supply and control cables were wired from a high-voltage power supply located at a power supply building north of the Nishina Memorial building to a tetrode RF amplifier installed at the D-corridor in December. The high-power RF test was also successfully completed without any serious problems and the BEA system began operations for the SHE experiment from December 2017.

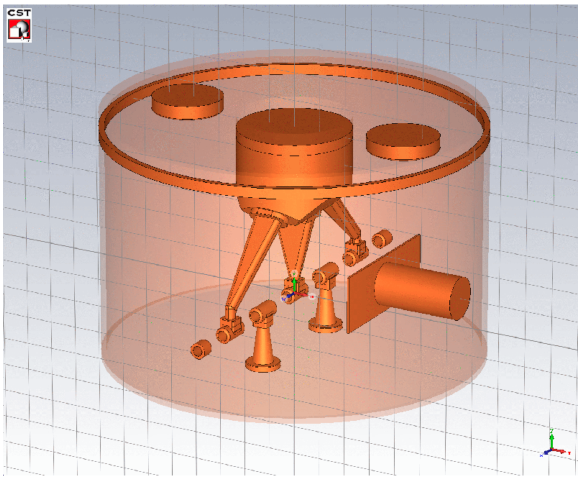

Fig. 1. A model with spacer rings used in the MWS calculation.

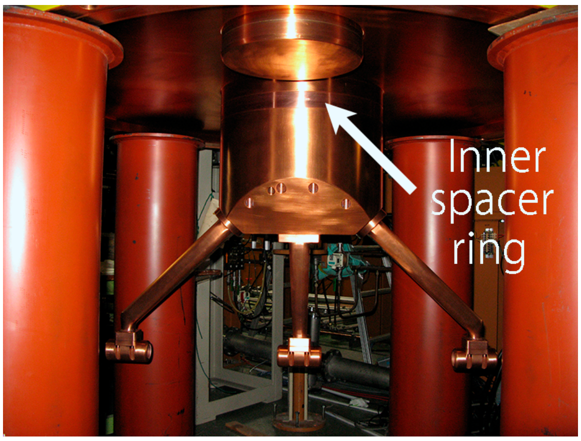

Fig. 2. Inner components of the remodeled cavity.

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