3-3 Fulfillment of ITER Criteria for RF Energy Transmission Efficiency

—Development of Electron Cyclotron Heating and Current Drive for ITER—

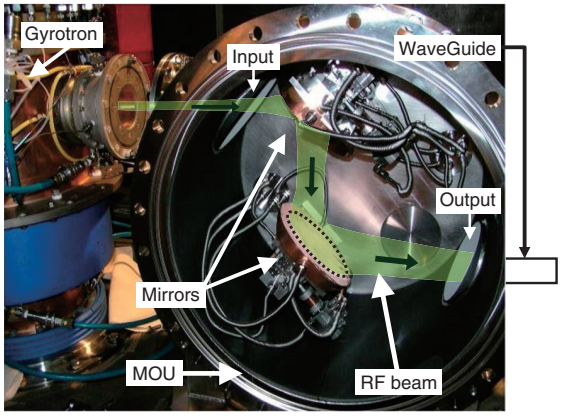

Fig.3-8 Modified MOU
The RF beam delivered from the gyrotron was injected to the corrugated waveguide through a couple of mirrors in the MOU. High purity of the HE_{11} mode was achieved by precise mirror adjustment.

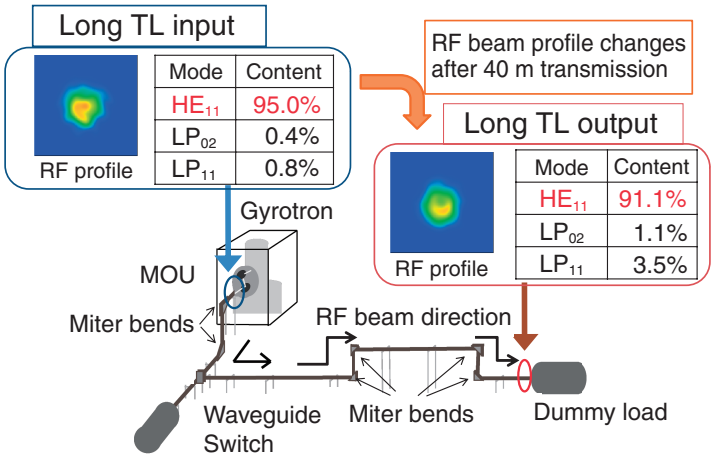

Fig.3-9 Configuration of high-power TL and RF beam profile and mode content at the TL input and output
The TL includes four miter bends, a couple of polarizers, and a waveguide switch. After transmission over 40 m of the TL, the RF field profile had a single peak and high HE_{11} mode purity was maintained.

The electron cyclotron heating and current drive (EC H & CD), which is a tool for heating and sustaining the plasma by a high-power millimeter wave, is a major heating system in the ITER. In the ITER, 1 MW/170 GHz RF power generated by the gyrotron is transmitted to the fusion plasma by a transmission line (TL) that is more than 100 m long. To achieve high transmission efficiency in the long - distance TL that includes a corrugated waveguide system (diameter: 63.5 mm), high purity of the fundamental transmission mode (HE_{11} mode) should be realized so that transmission loss is minimized.

For this purpose, we fabricated an ITER-relevant high-power, long-distance TL test system, performed an experiment for improving the HE_{11} mode purity, and demonstrated high-efficiency high-power RF transmission. First, we modified the matching optics unit (MOU) to improve the HE_{11} mode purity. The MOU includes two mirrors that transfer the RF power from the gyrotron to the corrugated waveguide, as shown in Fig.3-8. Using the modified mirror adjustment mechanism, we optimized the mirror angles and achieved an HE_{11} mode purity of 95%. Next, we estimated the influence of long-distance power transmission on the mode purity by using the transmission system shown in Fig.3-9. A high HE_{11} mode content of 91% was maintained at the end of the 40 m long TL when the mode purity was 95%. The total power in the unwanted higher-order modes (LP_{02}, LP_{11}) that were generated was 4%, which was acceptable for the ITER.

Finally, the transmission efficiency was measured. The transmitted power was measured by the dummy load installed at the end of the TL. The transmission loss was also identified by measuring the heat deposition in the intermediate components. From the results, the transmission efficiency was confirmed to be 96%, which well exceeded the ITER requirement.

Reference

Takahashi, K., Oda, Y. et al., High Power Millimeter Wave Experiment of ITER Relevant Electron Cyclotron Heating and Current Drive System, Review of Scientific Instruments, vol.82, issue 6, 2011, p.063506-1-063506-7.