§48. Preparation and Improvement of Heating System for Higher Performance Plasmas in the Large Helical Device

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In FY2015, preparation and improvement of heating systems aiming higher performance plasmas were accomplished. In regard to the ECH system, a new antenna mirror set for a planned new high power gyrotron was designed. With this antenna, we will obtain another new injection route from an O-port. Considering the present layout of the transmission lines and the situations of the O-ports, 9-O port was selected. Most part of the present transmission line for 82.7 GHz #11 gyrotron will be reused and the final section will be modified to reach the 9-O port. As shown in Fig. 1, the designed antenna consists of three mirrors M1, M2, and M3. The M3 is slightly convex so that the EC-wave beam emitted from the waveguide mouth is expanded a little further than a regular Gaussian beam. The concave mirror M2 makes the beam focused, and the beam direction can be steered by the plane mirror M1. At this moment the frequency of the next gyrotron is not decided, so the mirrors were designed to be dual-use for both 77 and 154 GHz EC-waves. Figure 1 shows the designed evolutions of the radii of 77 and 154 GHz EC-wave beams emitted from the waveguide mouth at the 9-O port. The horizontal axis denotes the distance along the EC-wave beam paths measured from a supposed focal point position at R = 3.6 m in the horizontally elongated poloidal cross section. In the case of 77 GHz waves, the beam radius is focused to its minimum value 65 mm in the plasma core region, at R = 3.6 m. In the case of 154 GHz waves, the beam radius becomes minimum outside the plasmas, however, the radius 42 mm at R = 3.6 m is small enough for the physics experiments. The antenna mirrors are now under manufacturing and they will be installed in FY2016. Possibility of using the new 9-O antenna for power injection of 77 GHz wave, which is now injected from 5.5-U top port, during the period before the future installation of the new gyrotron, is under consideration. To enable the selection of both 5.5-U and 9-O routes, a waveguide switch in the present 5.5-U transmission line and a new transmission line between the switch and 9-O port are necessary.

In regard to the ICH system, additional ex-vessel impedance transformers (EVIT) were installed in the power transmission lines of FAIT U and L antennas, as seen in Fig. 2. The diameters of inner conductor and outer conductor, and the length of the EVIT are 186, 241, and 628 mm, respectively. The maximum voltage in the co-axial transmission line can be lowered by reducing the reflected power, and the antenna load resistance can be increased. As a result, a higher injection power becomes possible under the voltage limit of the transmission line. For the HAS antennas, the EVITs were already installed in 2014 and it was confirmed that the antenna resistance was increased by a factor of ~1.7. In the case of the FAIT antenna, the antenna resistance is estimated to be increased by a factor of ~2.5. So far, the highest injection power from one of the FAIT antenna, the FAIT-L antenna, was 1.14 MW, and much higher power up to 1.8 MW is expected in the next experiment campaign.

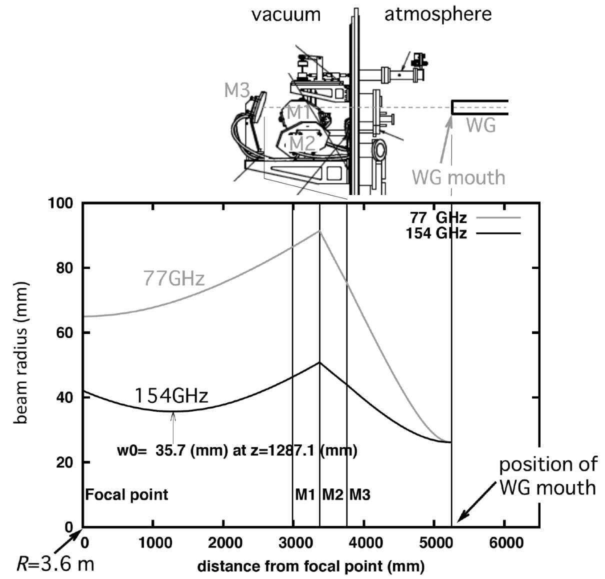

Fig. 1. Designed evolutions of the radii of 77 and 154 GHz EC-waves emitted from a waveguide mouth at the 9-O port. A schematic view of the mirror antenna system is also seen.

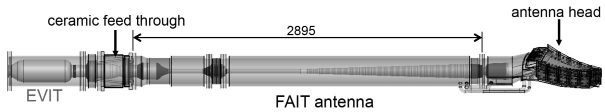

Fig. 2. Ex-vessel impedance transformer (EVIT) installed in the transmission line of the FAIT antenna. The vacuum boundary is the ceramic feed through, and the EVIT is placed outside the LHD vacuum vessel.

Acknowledgements

The authors would like to express their thanks to NIFS staff for performing the LHD experiments. This work was supported by the LHD project (NIFS ULRR701, ULRR703, ULRR801, ULRR804, ULRR806, KLPR016, KLPR030).